JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

ASSOCIATION OF FOOD SCIENTISTS & TECHNOLOGISTS, INDIA

VOL. 13 NO. 3

MAY–JUNE 1976

ASSOCIATION OF FOOD SCIENTISTS AND TECHNOLOGISTS

(INDIA)

The Association is a professional and educational organization of Food Scientists and Technologists

AFFILIATED TO THE INSTITUTE OF FOOD TECHNOLOGISTS, USA

Objects:

1. To stimulate research on various aspects of Food Science and Technology.
2. To provide a forum for the exchange, discussion and dissemination of current developments in the field of Food Science and Technology.
3. To promote the profession of Food Science and Technology.

The ultimate object is to serve humanity through better food.

Major Activities:

1. Publication of Journal of Food Science and Technology—bi-monthly.
2. Arranging lectures and seminars for the benefit of members.
3. Holding symposia on different aspects of Food Science and Technology.

Membership:

Membership is open to graduates and diploma holders in Food Science and Technology, and to those engaged in the profession. All the members will receive the Journal published by the Association. Regional branches of the Association have been established in Eastern, Northern, Central and Western zones of India.

Membership Subscription				**Annual Journal Subscription**		
Life Membership		**Rs**	**250**	**Inland**	**Rs**	**60**
Corporate Members				**Foreign:**		
(for firms, etc.)	**(per year)**	**Rs**	**250**	**Surface Mail**	**$**	**15**
Members	**„**	**Rs**	**15**	**Air Mail**	**$**	**22.50**
Associate Members						
(for students, etc.)	**„**	**Rs**	**10**			
Admission	**„**	**Re**	**1**			

For membership and other particulars kindly address

The Honorary Executive Secretary
Association of Food Scientists and Technologists, India
Central Food Technological Research Institute, Mysore-13, India

The Journal of Food Science and Technology is a bimonthly publication of the Association of Food Scientists and Technologists, India (AFST) issued in February, April, June, August, October and December.

Manuscripts for publication and books for reviewing in the Journal should be addressed to the Editor, Journal of Food Science and Technology, AFST, Central Food Technological Research Institute, Mysore-570013. The Editor reserves the privilege of editing the manuscript to make it suitable for publication in the Journal.

Correspondence regarding subscriptions and advertisements should be addressed to the Executive Secretary, AFST, Central Food Technological Research Institute, Mysore-570013, India. Payment may be made by cheque, draft, postal or money order in favour of Exec. Secretary, AFST.

JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

Volume 13 Number 3 May-June 1976

CONTENTS

Research Notes

REVIEW

Brewing with Enzymes

B. A. SATYANARAYANA RAO AND V. V. L. NARASIMHAM*
Central Food Technological Research Institute, Mysore

Traditional brewing is in practice over centuries. The raw material used in brewing is barley malt. Malting is an expensive process which involves soaking of barley grain, germination followed by kilning. With the increasing knowledge about enzymes and improved technology brewers are employing the microbial enzymes to mash barley and other cheaper starchy materials and obtain wort similar in character to all-malt wort. New developments in he production of barley and other syrups have thrown open other fermentable sources for the manufacture of beer.

In any technological process, economics play a dominant role in deciding the cost of the final product. Brewing technology is no exception to this. The chief raw material used in brewing is barley malt. The cost of the barley grain gets doubled in the process of malting. Besides providing desirable characters such as flavour, colour, etc., conversion of barley grain to malt gives rise to the production of various enzymes during germination. Among these are included proteases and amylases. Activities of these enzymes are very well known. Some microbes are known to produce these enzymes in considerable quantities under appropriate conditions. If these microbial enzymes could be used in brewing, considerable quantity of malt can be replaced by barley grain or other starchy materials with advantage. The cost of production could be reduced which in turn, lowers the cost of the finished product.

An attempt has been made in this review to give a brief outline of the enzymes produced during malting, their functions during wort preparation and the use of microbial enzyme during brewing and the advantage in using them.

Brewing is an age-old art. The brewer's most important raw material has always been barley grain which is converted into malt by steeping, germination and kilning. This process, known as malting, involves soaking of barley grains in water at a temperature of about 12°C for 36 hr with frequent aeration; the wet barley is germinated around 14°C for a period of about 144 hr and later kilned at a temperature not exceeding 85°C to limit the moisture content of malt to about 4 per cent. Many enzymes are developed during germination and some of them are destroyed during kilning. During this process malt develops desirable flavour and colour. Malting aids in providing adequate quantity of fermentable material during wort production and affords nutrients for yeast during fermentation and contributes desirable organoleptic properties to beer[1]. Other ingredients used in the production of beer apart from the malt are hops and adjuncts such as barley, rice, maize, rye, sugar, etc.

Traditional practice of brewing: Malted barley is crushed carefully in a mill in such a way that the contents inside the husk become a very coarse flour leaving the husk intact. The crushed material is mashed to extract the contents. This is achieved either by the infusion mashing process or by the decoction mashing process[2].

Infusion mashing: This process which is common in Britain, involves grinding malt and a smaller amount of unmalted cereal used as adjunct preferably in a precooked condition. The ground material called grist, is intimately mixed with water usually 2.5 times the weight of grist and held at a temperature of 52°C for 30 min and raised to 63°C in about 20 min and this temperature is maintained for about 60 min; it is further raised to 78°C in about 40 min and held for 10 min before being allowed to run into a lauter tun.

Decoction mashing: This differs from infusion mashing in many respects. Malt is ground more finely than in the infusion process; grist is mixed with water at about 35-40°C. One third of the mash is transferred to a mash copper and the temperature is increased gradually to about 70°C, then boiled and transferred back to the original vessel and mixed. The overall temperature by this time increases to around 50°C. After allowing to stand for some time one third of the mash is again transferred to the mash copper and boiled as before. When put back to the main mash the temperature will have increased to about 75°C. The entire mash is boiled before separating the grain from the wort in a lauter tun. Mashing temperature depends on the type of malt and adjuncts used.

Sweet wort obtained by either of the process is then boiled with hops to extract the bitter principles of hops. Sugar is added if necessary. Spent hops are separated.

*M/s. Hindusthan Milk Food Manufacturers Ltd., Bommuru, Rajmandhri, A.P.

Hopped wort is cooled, filtered and pitched with a elected strain of brewer's yeast and fermented.

le, common in Britain, is produced by fermenting at 15-20°C hopped wort obtained by infusion mashing and using top yeast (*Saccharomyces cerevisiae*). Lager beer common in Europe is produced by fermenting at 10-15°C hopped wort obtained by decoction mashing and using bottom yeast (*Saccharomyces carlsbergensis*). Chemical and biochemical changes taking place during fermentation by yeast is too well known.

Enzymes and their action during malting: During germination, significant biochemical changes take place. These include the synthesis of several hydrolytic enzymes such as carbohydrases and proteolytic enzymes. Unmalted barley contains considerable amounts of β-amylase, while ∝ -amylase is formed during germination. A limited degradation of reserve starch takes place during germination. Proteolytic enzymes degrade proteins to polypeptides and amino acids. Oxidases and peroxidases increase during malting and play important role in the development of colour during wort production. Hemicellulases and in particular β-glucanases formed during malting, degrade β-glucans of barley to low molecular glucose polymers. The decomposition products of protein play significant role in determining the characteristic of beer, viz., foam, haze, flavour, etc. Amino acids are valuable nutrients to yeast cells. Thus barley is modified considerably during malting including kilning.

Enzyme action during mashing: Proteolytic and amylolytic enzymes play significant role during mashing. Proteolytic action initiated during malting will be completed during mashing resulting in the solubilisation of amino acids. Gelatinisation, liquefaction and hydrolysis of starch take place by the action of appropriate enzymes. Degradation of starch to fermentable sugars is the major biochemical change that takes place. Degraded products of starch and the important enzymes involved are shown in Fig. 1.

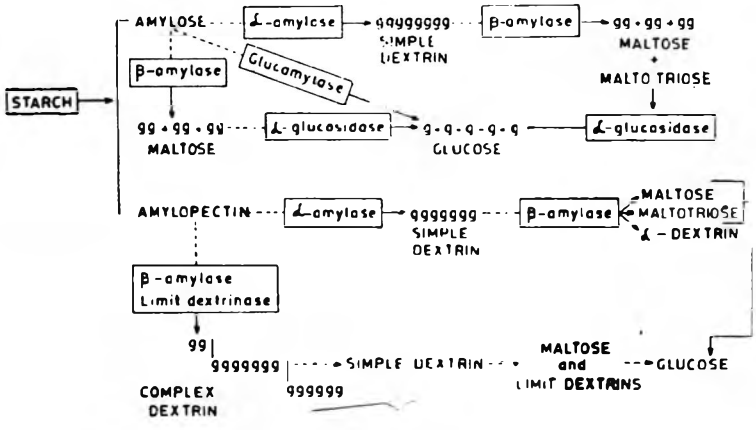


Fig. 1. Degradati ' and the enzymes involved.

The efficiency of mashing depends upon several factors—temperature, pH, concentration of the mash, composition of the grist, etc. The rates of solubilisation of starch, extraction of the hydrolytic enzymes from the malt, hydrolysis of starch and thermal inactivation of the enzymes are all governed by the exact conditions of mashing and any alterations in the programme affect the final product, unless the conditions are modified suitably. The starch degrading enzymes differ in their optimum pH and temperature requirements and hence any variations in the pH of the mash or alteration of temperature affect the characteristic action of the enzymes during mashing. Boiling of wort, however, destroys all the enzymes.

Malt substitutes and brewing with enzymes: Unmalted barley is one of the adjuncts used in brewing. Investigations[3–8] have been carried out to alter and increase the proportion of barley to malt so that the enzymatic activities of malt could be exploited to the maximum. However, a loss of extract, prolonged time of saccharification and an increase in the viscosity with the increased amount of barley was noticed. By employing special malts very rich in diastatic power these defects are reported to have been corrected[9].

The capital cost of malting plants are high and malting losses during processing are also considerable. A new chapter in the field of brewing is opened with the increasing knowledge about enzymes, in particular about the starch splitting and proteolytic enzymes. These essential enzymes needed during mashing can now be obtained from microorganisms. In order to reduce the viscosity of wort, cytolytic enzymes of *Tricothecium reseum* have been used by Salmonova *et al.*,[10] when unmalted barley was used as on adjunct. When part of the malt was replaced by maize, saccharification of starch has been reported to be achieved by using Japanese amylase admixed with *Aspergillus oryzae*.[11] The yield of extract has been reported to be lower by 5-10 per cent than when malt enzymes and *Aspergillus oryzae* were used. Enevoldsen[12] observed that experimental mash of ungerminated barley with 5-10 per cent malt and with the addition of debranching enzyme pullulanase gave good yield of wort with high degree of attenuation.

With the advent of microbial enzymes attempts[13–19] have been made to use bacterial proteases and bacterial amylases and fungal amylases and glucamylases during mashing and wort production when part of the malt has been replaced by unmalted barley grain. The object is to replace malt by a large quantity of unmalted barley or feed barley or any cheaper starchy grain so that expensive malt could be conserved, and wort characters would not alter much from all-malt wort. Total replacement of malt is unrealistic and according to Sorensen[20] about 50-60 per cent replacement of malt by unmalted

barley has been found to be suitable to produce wort and later beer.

Process of brewing with enzymes: The barley-malt mixture was mashed at 52°C with the addition of bacterial amylases and proteases[29]. Enzymes were dissolved in water immediately prior to addition. Where adjunct was used, it was separately liquefied by using bacterial amylase. Enzymes were stabilised by adding calcium hydroxide. Liquefied adjuncts were then mixed with the mash and the pH was adjusted to 5.6 by addition of phosphoric acid and saccharification was carried out for 60 min at 63°C. The temperature was then raised to 70°C and maintained until complete saccharification took place as indicated by the absence of staining iodine and the mashing was completed at 78°C, the entire operation lasting about 180 min. Filteration was found to be normal and the clear wort was hopped as usual, freed from spent hops and hopped wort on cooling was fermented with yeast in the usual way. The fermentation was completed in about 6 days at 10°C.

Prevalence of aerobic *Streptococci* has been found[21] to be much more in American malts than in barley and use of larger quantity of unmalted barley and use of microbial enzymes seemed to have minimised the hazards of bacterial contamination.

FDA of the United States considers[20] that amylases and proteases produced from *Bacillus subtilis*, *Aspergillus niger* and *Aspergillus oryzae* are safe for use in food industry provided foods are produced from sound raw material and in accordance with good manufacturing practice. The British Biological Research Association has confirmed that bacterial amylase in the brewing industry does not constitute any risk to health. The concentration of enzymes used in brewing will be in the range of 0.05 to 0.5 per cent based on the dry weight of the raw material. The concentration of the enzymes in the finished product (beer) will be far less. Enzymes added in the mash tun will be destroyed during boiling of wort and will not occur in active state in the finished beer.

When microbial enzymes are employed, certain technological modifications become necessary during mashing and wort production. Attempts have been made to use wet-milling of barley[22,23,28,29], preservation by the use of sulphur dioxide[23] steeping barley for different periods[24,27,30], alteration of water: grain ratio[24,30], etc. Filtration of wort has been reported to be normal in most cases and in some settling of yeast has been found to be better than in control.

It is a general practice to use yeast for 8 to 10 successive generations in brewing. In pilot plant studies conducted by Brenner[28] using microbial enzymes for mashing, 13 generations of yeast have been used with normal rate of fermentation and without any deleterious effect on beer.

Quality of beer: Lautenbauch and West[31] claim to have obtained higher yield of extract when wort was prepared using 20 per cent corn grist and 80 per cent malt with the addition of microbial enzyme preparations. Macey and coworkers[32] published a report on brewing tests with 100 per cent unmalted barley using bacterial enzyme preparation containing both amylase and protease. However, incorporation of 5 to 10 per cent malt is reported to have given better results. Klopper[33] noticed insufficient saccharification when 100 per cent barley was brewed along with bacterial protease and amylase; incorporation of 10 per cent malt improved the situation. A satisfactory beer is reported[25,26,30] to have been made both on pilot and full scale from wort prepared from 25 per cent malt, 25 per cent maize grist and 50 per cent barley along with bacterial enzyme preparation containing a mixture of protease and amylase. Addition of glucamylase[17,25,26,34] seemed to have increased the fermentability of the wort.

Klopper[33] observed a high level of diacetyl content, improved foam stability and reduced colloidal stability in the beer. An increased resistance against chill haze formation has been noticed[29] on adding glucamylase. The low fermentability of barley wort was fully compensated by the addition of fungal α-amylase and the apparent attenuation of the beer has been reported[29] to be approximately 1.5 per cent more than that of the control. Organoleptically barley beer (brewed with microbial enzymes) has been found[16,18,19,29,30,36,37] to compare favourably with control beer (all-malt beer), though according to Brenner[28] control beer was more aromatic and estery than barley beer. It has been found that barley beer could be lagered, filtered and finished in the normal way. Though the colour is reported to have been paler, the colour stability has been found to be better than that of control beer. Studies made by Dubiel and Golebiawski[38] have indicated that beer of good flavour could be obtained using unmalted barley upto 50 per cent with malt and purified amylase. About 25 per cent saving in filtration time was achieved by Enkenlund[39] and Ducroo and Delecourt[40] when β-glucanase was added during mashing.

Brenner[28] has schematically shown (Fig. 2) the proportion of barley to be used and the quality of beer expected when brewed along with microbial enzymes. Replacement of malt by unmalted barley upto 60 per cent, according to the author, is expected to yield very good beer when brewed with microbial enzymes.

Mash cycle of barley brew as shown in Fig. 3 has been found[29] to fit 8 brews per day schedule. The exact temperature and time were not found critical within the recommended temperature maxima. Prolongation in the mash cycle has been found to increase the fermentability of the wort.

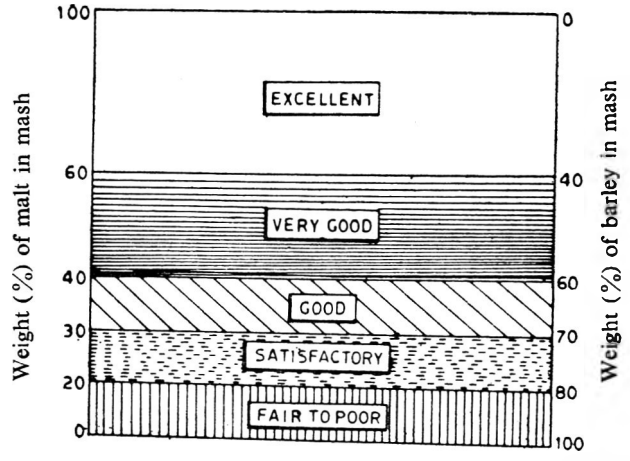


Fig. 2. Proportion of barley and malt and the quality of beer expected.

Wort substitutes: It has been suggested that barley worts could be replaced by wort substitutes often called "commercial brewer's concentrate" or "syrups" produced by using microbial enzymes and starchy materials. These syrups are intended to provide a complete wort on dilution and, therefore, must contain all the components present in all-malt wort both in quality and quantity. Unmalted cereals like, barley, wheat, maize, rye, rice, etc. have been recommended[24,41,42] for the production of syrups. Associated British Maltsters, and D.Ds-Kroyer A/S Copenhagen have jointly developed a process for making glucose syrup. Based on this process Noerr[43] has developed a know-how for the manufacture of barley syrup utilising microbial enzymes and malt enzymes. The product is claimed to be relatively of light colour with pleasant mild flavour and the wort is indistinguishable in character from all-malt wort. If a plant with a capacity of 10,000 tons a year of barley syrup with a dry solids content of 77 per cent at a capital investment of $7,83,000 is established then the cost of barley syrup per ton is expected to be $132. One ton of barley syrup (77 per cent dry solids) is claimed to be

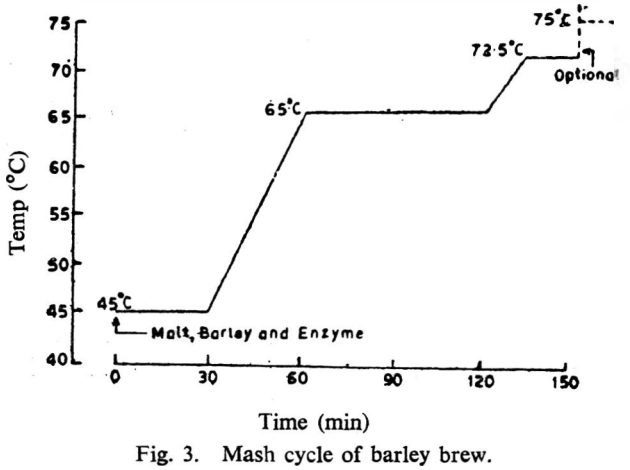


Fig. 3. Mash cycle of barley brew.

equivalent to 1 ton of wort (77 per cent dry solids) derived from 1 ton of malt, the cost of the malt being $168 a ton. If the plant is located adjacent to a brewery utilising the other facilities of a brewery the unit price per ton is approximately $124.

Commercial concentrates could even be powdered after adding bitter substances. For the manufacture of beer from concentrates or dried products, the concentrate is diluted with water or the dried powder is dissolved in water to the normal strength of the wort required for fermentation. The following advantages are attributed to the use of barley syrup in the production of beer:

(*i*) Production of uniform extract from barley of variable quality.

(*ii*) Utilization of low grade feed barley.

(*iii*) Capital investment per unit of output is less for an extract plant than for a malt plant.

(*iv*) Elimination of mash tuns in the brew house and thus reducing the cost of new brew house.

(*v*) An increase in the output from the existing brewery at a minimum cost.

(*vi*) Elimination of malting losses and the cost associated with it.

(*vii*) Flexibility in the operation and use of relatively simple equipment.

Technical and commercial aspects of production of brewing syrups have been given by Crisp and East[44] and utilization of similar syrups for the production of beer are reported[15,34,45–47].

Economic implications: In order to deviate from the traditional practice and adopt newer concepts, there should be some strong motivation. In the case of malt substitutes or brewing with microbial enzymes it is mostly economics that is involved. The cost of malt is considerably high, almost double, compared to the cost of barley. This fact has prompted the brewers and technologists to work out new processes.

The total (dry basis) barley extract is reported[28] to be quite close to that of malt produced from it and 1.12 kg of barley is required potentially to replace 1 kg of malt and the ratio would lie between 1.1:1 and 1.25:1. This is attributed to two factors. One is that the starch of barley is less readily attacked by enzymes than that of malt. The second factor is that it might be a feed barley used for brewing. Keeping barley to malt ratio, at a level of 1.2:1 the author has worked out the cost difference in processing and has shown an economy of 19 cents per barrel of the wort produced from malting quality barley. Savings could be increased to 36 cents per barrel of wort when cheaper feed barley is used. According to Hansen[29] a savings of 1.07 Denmark Krones per hectolitre of wort could be made indicating the usefulness of brewing with microbial enzymes.

Entrapped enzymes[47] have opened a new vista in the

field of technology. The importance of this system can be well appreciated when starch solution liquefied with ∝ -amylase was recycled through a column containing glucamylase entrapped in fibres to achieve 98 per cent conversion and further the same fibre was used 4 months at 45°C on maize starch without appreciable fall in activity. At present, this has remained a scientific curiosity and perhaps in course of time the method may be exploited for the continuous production of wort and beer. It is not possible at this stage to look into the economics or the quality of the product but there is a great future for such a process.

Conclusion: Brewing in the traditional way is in vogue both in Europe and America since centuries. Knowledge of brewing in our country is imported. In fact, earlier breweries were set up with foreign collaboration and therefore, traditional methods of brewing have been adopted in our breweries. However, technological advancement have made it possible for producing food enzymes in our country and with the R & D efforts, newer approaches should be made to produce beer with advantage. Brewing with enzymes is of recent origin. There is great scope for exploiting this new process with advantage. Barley syrups or syrups from other cheaper starchy substances if on dilution yield wort similar to all-malt wort in the carbohydrate content, amino acid content and other physicochemical characters, then the entire brewhouse can be dispensed with and the operation will be restricted to fermentation only. Storage facilities of malt can be minimised. Fermentation can be done as and when required. Smaller units with fermentation facilities can be installed at a lower cost.

References

1. Preece, I.A., *Biochemistry of Brewing*, Oliver & Boyd, Edinburgh and London, 1958.
2. Hough, J. S., Briggs, D. E. and Stevens, R., *Malting and Brewing Science*, Chapman and Hall Ltd., London EC4, 1971.
3. Hudson, J. R., MacWilliam, I. C. and Birt Wistle, S. E., *J. Inst. Brew.*, 1963, **69**, 308.
4. Mostek, T. and Dyr, J., *Wallerstein Labs Commun.*, 1966, **26**, 70.
5. Enari, T. M., *Wallerstein Labs Commun.*, 1967, **30**, 5.
6. Scully, P.A.S. and Lloyd, M. J., *Wallerstein Labs Commun.*, 1967, **30**, 154.
7. Tadeusz, G., Barbara, S. and Elzbiela, T., *Przem. Ferment Rolny*, 1967, **11** (3), 81 (*Chem. Abstr.*, 1967, **67**, 31546V).
8. Pollock, J.R.A., *Brauwissenschaft*, 1971, **24**(5), 158 (*Fd Sci Technol Abstr.*, 1971, **3**, 10H 1436).
9. Lewis, M. J., *Process Biochem.*, 1968, **3**, 47.
10. Salmonova, L. S. and Zadonova, L. A., *Ferment Spirt. Prom.*, 1971, **37**(5), 15 (*Chem. Abstr.*, 1971, 75, 150285 J).
11. Yakovenko, V. A., Roshak, M. V. and Romenskii, N. V., *Izv. vyssh. uchebn Zaved. Pischchevaya Technol*, 1970, **5**, 93 (*Fd Sci. Technol. Abstr.*, 1971, **3**, 7H 1020).
12. Enevoldsen, B. S., *J. Inst. Brew.*, 1970, **76**, 546.
13. Bley, W., Hofmann, M. and Lother, H., *Int. Brewers' J.*, 1970, **106**, 67 (*Fd Sci. Technol. Abstr.*, 1971, **3**, 2H 150).
14. Bley, W., Hofmann, M. and Lother, H., *Kvasny Prum*, 1970, **16**, 102 (*Fd Sci. Technol. Abstr.*, 1971, **3**, 4H 506).
15. Anon, *Int. Brewing Distilling*, 1972, **2**, 44 (*Fd Sci. Technol. Abstr.*, 1972, **4**, 11H 1760).
16. Nielsen, E. B., *Proc. Eur. Brew. Conv.*, 1971, **13**, 149.
17. Hollo, J., Laszlo, E., Tolk, M. and Wieg, A. J., *Dechema-Monogr.*, 1972, **70**, 231 (*Chem. Abstr.*, 1972, **77**, 124726a).
18. Germany, W., British Patent: 1236809-1971 (*Fd Sci. Technol. Abstr.*, 1972, **4**, 3H 382).
19. Pfenniger, H. B., Schur, F. and Wieg, A. J., *Proc. Eur. Brew. Conv.*, 1971, **13**, 171.
20. Sorensen, S. A., *Process Biochem.*, 1970, **5**, 61.
21. Shirk, E., *Appl. Microbiol.*, 1970, **20**, 20.
22. Brenner, M. W., *Brewers Guardian*, 1972, June 47.
23. Wilt, P. Jr., *Brewers Dig.*, 1970, **45**, 48 (*Chem. Abstr.*, 1970, **73**, 33846 7).
24. Wieg, A. J., *Process Biochem.*, 1970, **5**, 46.
25. Mozga, T., *Pr. Instwz Lab. badaw. Przem. roln. spozyw.*, 1970, **20**, 179 (*Fd. Sci. Technol. Abstr.*, 1971, **3**, 8H 1106).
26. Mozga, T., *Przem. Ferment. Rolny*, 1970, **14**(12), 1 (*Fd Sci. Technol. Abstr.*, 1971, **3**, 8H 1107).
27. Pfenniger, H. B., *Naarden News*, 1972, **23**(232), 2 (*Fd Sci. Technol. Abstr.*, 1972, **4**, 7H 1068).
28. Brenner, M. W., *Master Brewers Ass. Am. tech. Quart.*, 1972, **9**, 12.
29. Hansen, M., *Brygmesteren*, 1972, **3**, 65.
30. Wieg, A. J., *Master Brewers Ass. Am. tech. Quart.*, 1973, **10**, 79.
31. Lautenbauch, A. F. and West, O. B., *Wallerstein Labs Commun.*, 1960, **23**, 47.
32. Macey, A., *Proc. Eur. Brew. Conv.*, 1967, **11**, 283.
33. Klopper, W. J. *Int. Tijdschr. Brouw. Mout*, 1968, **27**, 143 (*Chem. Abstr.*, 1968, **69**, 75577b).
34. Pollock, J.R.A., *Brauwissenschaft*, 1971, **24**, 158 (*Fd Sci. Technol. Abstr.*, 1971, **3**, 10H 1436).
35. Klopper, W. J., *Wallerstein Labs Commun.*, 1955, **18**, 123.
36. Mart'yanova, L. A. and Gracheva, I. M., *Izv. Vyssh. ucheb. Zaved, Pishchevaya Technol.*, 1971, **3**, 40 (*Fd Sci. Technol. Abstr.*, 1972, **4**, 6H 882).
37. Basarova, C. and Bendova, O., *Kvasny Prumysl*, 1971, **17**, 176. (*Fd Sci. Technol. Abstr.*, 1972, **4**, 6H 796).
38. Dubiel, L. and Golebiawski, T, *Pr. Instw. Lab. badaw. Przem. roln spozyw.*, 1970, **20**, 371 (*Fd Sci. Technol. Abstr.*, 1971, **3**, 8H 1170).
39. Enkenlund, J., *Process Biochem.*, 1972, **7**, 27.
40. Ducroo, P. and Delecourt, R., *Bull. Inst. Ferment.*, 1971, **14**, 133 (*Chem. Abstr.*, 1972, **77**, 112424n).
41. Imrie, F. K., *Process Biochem.*, 1968, **3**, 21.
42. Samuel, R. G. *Master Brewers Ass. Am. tech. Quart.*, 1969, **6**, 33.
43. Noerr, N. J., *Master Brewers Ass. Am. tech. Quart.*, 1971, **8**, 134.
44. Crisp, J.W.M. and East, E., *Proc. Eur. Brew Conv.*, 1971, **13**, 185.
45. Sfat, M. R. and Morton, B. J., U. S. Patent: 3, 711, 292-1973 (*Chem. Abstr.* 1973, **78**, 82944h).
46. Brenner, M. W., S. African Patent: 7107423 (*Chem. Abstr.*, 1973, **78**, 56445b).
47. Dinelli, D., *Process Biochem.*, 1972, **7**, 9.

Fermentative Production of Cheese-like Flavour Concentrate by *Candida lipolytica*

G. P. KALLE, S. Y. DESHPANDE AND (MRS) B. Z. LASHKARI
Hindustan Lever Research Centre, Andheri, Bombay-93

Manuscript Received: 19 *December* 1975

A process for the development of a flavour concentrate characteristic of a processed cheese by fermentation of cream with *Candida lipolytica* strain C_1B has been described. The process consisted of growing the yeast in whey medium under the conditions which stimulated optimum synthesis of a cell-bound lipase and an extracellular proteinase, and inoculating it into a cream standardised to about 60 per cent fat. There was a good correlation between the increase in free fatty acids (FFA) of cream and flavour development which was complete within 45-50 hr. There was very little proteolytic activity as measured by increase in acid-soluble tyrosine during fermentation. Analyses of fatty acids in fermented cream by GLC showed a reasonably close similarity to Cheddar cheese flavour except for the absence of acetate and presence of a number of unsaturated fatty acids. The flavour concentrate could be used as an additive for the preparation of processed cheese from freshly prepared rennet curd made from standardised or skim milk. The process is particularly adaptable for India because of its low cost of manufacture and inherent flexibility in operation since the flavour which is prepared independent of any cheese process can be used with other dairy or non-dairy products.

In India, taste for cheese is an acquired one limited only to sophisticated urban markets and is confined primarily to the processed cheese. In western countries, processed cheese is relatively a low cost product since it is made from varieties of ripened cheeses available in the market. In this country, it is made from curds ripened to different degrees with starter culture and blending them in right proportions with melting salts to produce cheese of right texture and flavour. Ripening times vary from 2-3 months to one year at controlled temperature depending upon the quality of the processed cheese entailing relatively large capital expenditure. In the process described here, a flavour concentrate is prepared by fermentation and added to the freshly prepared or unripened curd at the time of melting, thus introducing a greater flexibility and control over the quality of the processed cheese.

Biochemical changes which occur during ripening of cheese are well known and can be broadly associated with the products of breakdown of carbohydrates, proteins and fat of the milk curd[1,2]. Though the metabolites from the carbohydrate degradation contribute to the keeping quality and acidic taste of the curd, the cheesy flavour is derived from the products of enzymatic splitting of fat and proteins in a controlled manner[2-4]. It is, therefore, possible to produce cheesy flavour concentrates fermentatively by enzymatic breakdown of fat and to some extent milk proteins which could supplement the inadequacies in the flavour in partially ripened or unripened milk curds for the preparation of processed cheese. Conventional lactic starters used in the production of the processed cheese are unsuitable because most of these are either weakly lipolytic or proteolytic in nature[6,7]. Enzymes, particularly lipases, have been used to reduce the ripening times and improve flavour of cheese[8,9]. We have been interested in investigating unconventional "non-dairy" cultures which could be used in the fermentative production of the flavour.

In an earlier paper[10], it was shown that a *Candida lipolytica* strain produced both proteinase and lipase active against the substrates in the milk. Lipase activity in this strain was associated with the cells whereas proteinase was produced extracellularly during growth. Relative activities could be controlled by regulating their production through the use of suitable inducers. In the present paper, we describe our studies on the production of cheese-like flavour in buffalo cream (60 per cent fat) by fermentation using *C. lipolytica*. The profile of the fatty acids produced by lipolysis of the milk fat matched very closely to that reported for Cheddar cheese. Processed cheese prepared from freshly rennetted curd using the flavour concentrate made by fermentation has been found to be satisfactory in a commercial process[11].

Materials and Methods

Culture conditions: The growth conditions for the strain C_1B of *C. lipolytica* var *planta*, composition of the cheese whey medium, and production and assay of enzymes have been previously described[10]. Briefly it involves growing the culture on cheese whey medium containing 0.6 per cent yeast extract with aeration at 25°C for 30 hr. At this time, the proteolytic as well as

lipolytic activities reached maximum. It was then transferred to the presterilised cream containing 60 per cent fat and 4 per cent SNF (Solids-not-fat) to give a five-fold dilution.

Flavour production: Cream fermentations were carried out at 30°C in New Brunswick fermentor with constant stirring at 150 rpm but without aeration. Progress of fermentation was followed by the release of free fatty acids (FFA) and trichloracetic acid (TCA) soluble tyrosine.

Analytical methods: FFA was measured by titrimetric method of Frankel and Tarassak[12] for dairy products, and expressed as milli-equivalents per 100g of fat in cream. TCA soluble tyrosine was measured by treating 1 g cream diluted with 1ml water and treated with 3 ml of 5 per cent TCA solution in cold (at 4-6°C). After 5 min, the mixture was filtered and the filtrate assayed for tyrosine by the method of Lowry *et al*[13]. Release of TCA-soluble tyrosine was taken as an indication of extent of proteolysis during fermentation. Viable cells of yeast were assayed by plating on Sarboraud's agar plates.

Analysis of flavoured cream: Fatty acids from the cream were analysed on GLC by the method described by Bills *et al*[14]. This method was found to be rapid, simple and convenient for the analysis of flavour fatty acids. Cream samples were extracted with 50 ml hexane and stirred with 50 g resin for 30 min at 4°C. Resin was washed twice with chilled methanol and then extracted twice with 30 ml of methanol-HCl. Pooled eluates were extracted repeatedly with ethyl ether and the ether extracts refluxed at 30-35°C continuously to concentrate the mixture to about 5-10 ml. The concentrate was used directly for application to GLC columns. GLC analysis was carried out using a 2.74m $\times$0.3 mm O.D. column packed with 30 per cent PEGA on celite using a flame ionisation detector. For the preparation of the standards, 10 mg each of the fatty acids were dissolved in 50 ml hexane and analysed in identical manner as described for cream samples. All the steps except refluxing for concentration of the samples were carried out at low temperatures (about 4-6°C) to avoid flavour losses. Except acetaldehyde where losses mainly during refluxing were about 15-20 per cent, all other fatty acids could be recovered quantitatively from the cream.

Results

Growth characteristics: Whey is a natural medium for growing *C. lipolytica* because it is a low-value by-product of any cheese process. Whey supplemented with yeast extract was a good medium for cultivating the yeast. In this strain, lipase is cell-bound whereas proteinase is synthesised extracellularly. Relative

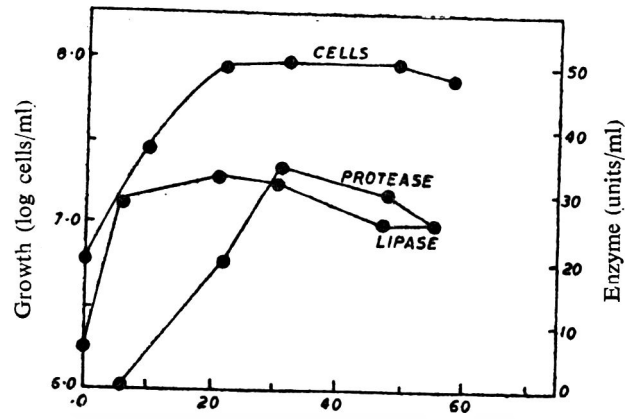


Fig 1. Proteinase and lipase activity during growth of *C. lipolytica* in whey medium supplemented with 0.6 per cent yeast extract.

activities of the two enzymes could be easily controlled by choosing the right conditions during growth or physically separating the two enzymes by centrifugation and remixing them in correct proportions. Since the proteinase synthesis resumed late during the growth, the ratio of activities of the two enzymes at any moment in culture medium varied between 0 at 6 hr to 1.5 at 48 hr (Fig 1). In our studies, a 30-hr culture was used when the ratio was about 1.0. At this stage, the culture was transferred to the cream to give a five-fold dilution.

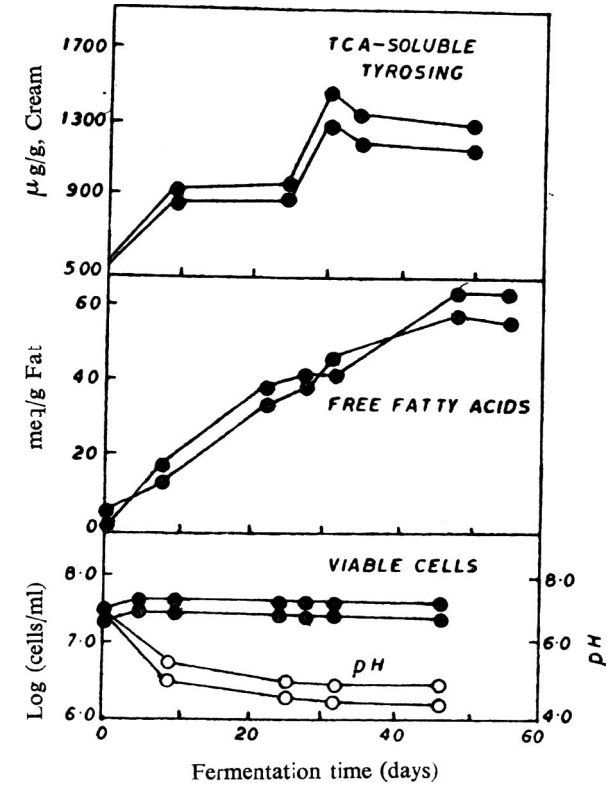


Fig. 2. Biochemical changes during cream fermentation.

Fermentation of cream: Flavour development in cream closely followed the increase in FFA and was maximum in about 50 hr (Fig 2). There was no increase or decrease in number of viable cells suggesting that the flavour changes were primarily associated with the lipolytic activity. No flavour was developed when skim milk devoid of fat was used as substrate. On the other hand, washed cells of the organism, which carried lipase activity but were free of detectable proteolytic activity, were able to produce cheese-like aroma in emulsified milk fat as a substrate. When the same cells were used against emulsified vegetable fat such as safflower or groundnut oil, no flavour was produced though these fats were hydrolysed extensively by the lipase from this strain[10]. Increase in acid soluble tyrosine was stepwise and only two-fold during 50-hr fermentation. This would be expected since the cream used in these studeis had only 2 per cent protein. If protein content was higher than this level, the cream tasted bitter. On the other hand, if only fat was used as a substrate, the fermented product appeared to lack certain taste components considered necessary for final cheese. This is not surprising since a number of amino acids and peptides are known to contribute significantly to the "basic cheese taste" of a variety of cheeses[4,16,17]. Higher amounts of the same amino acids imparted bitter taste and are probably desirable in some special cheeses[2]. A correlation between the degree of lipolysis as measured by the FFA content of the cream and subjective analysis of the flavour assessed by a panel is given in Table 1. All fermentations were carried out in New Brunswick fermentor.

Flavour analysis: Lipase of *C. lipolytica* has a broad substrate specificity[10] and yet there is a specific requirement for the milk fat in order to produce a cheese-like flavour. Fatty acids of the cream were, therefore, analysed to determine if there was any relationship between the types of fatty acids present and cheesy flavour. Use of anion exchange resins for separating flavour components and methylating them at lower temperatures permitted the quantitative recoveries of lower fatty acids particularly in the range of C_2 to C_4[14]. This was confirmed in an experiment where known quantities of lower fatty acids were absorbed on to the column, methylated and analysed by GLC. Recovery of fatty acids in the range of C_3-C_8 was about 95-97 per cent whereas that of acetaldehyde was about 80-85 per cent. There were apparently some loss of acetaldehyde during refluxing at 30°C. Analysis of the fatty acids in the fermented cream are given in Fig. 3 and 4. All the major peaks could be identified on the basis of their relative elution rates by comparison with the corresponding standards. There were also some minor peaks which were not identified, and their contribution to the overall cheese flavour could not be determined. It may be mentioned here that a number of carbonyl compounds,

TABLE 1. PRODUCTION OF FLAVOURED CREAM BY FERMENTATION

Expt. No.	Time hr	Yeast cells/ml	pH	FFA meq./100 g fat	Remarks
1	0	1.2×10^7	6.1	5.69	Mild cheesy
	48	2×10^7	4.2	19.5	
2	0	2×10^7	5.6	10.4	Good cheesy
	48	8.4×10^6	4.2	49.8	
3	0	1.9×10^7	6.1	7.24	Strong cheesy
	48	2×10^7	4.5	34.7	
4	0	2.8×10^7	6.6	6.7	Strong cheesy
	48	1.8×10^6	5.1	35.9	
5	0	5×10^7	6.25	7.87	Strong cheesy
	48	3.5×10^6	4.50	40.08	

Fermentor conditions: Temp. 30°C, stirring rate, 150 rpm. Quantity of cream: 4 kg; 60 per cent fat in cream.

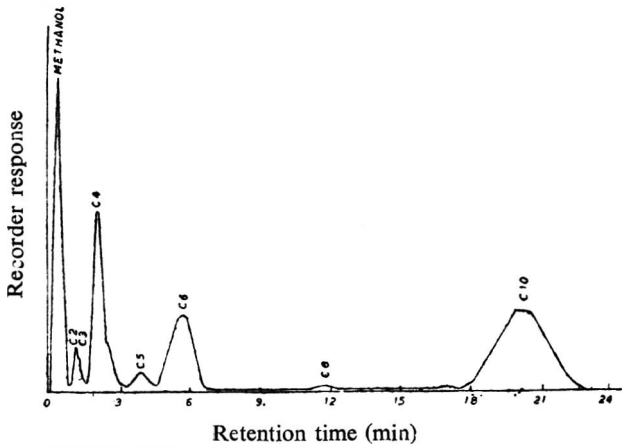


Fig 3. Gas chromatographic separation of methylated fatty acids formed in cream during fermentation.

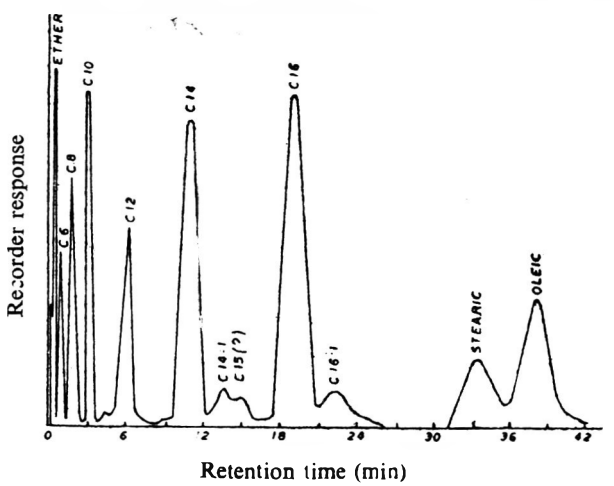


Fig 4. Gas chromatographic separation of methylated fatty acids formed during fermentation in cream.

TABLE 2. DISTRIBUTION OF FATTY ACIDS IN THE FERMENTED CREAM

Fatty acids carbon number	Flavoured[1] cream (%)	Cheddar[2] cheese (%)
2 : 0	1.20	32.53*
3 : 0		
4 : 0	5.70	6.36
5 : 0	0.46	—
6 : 0	3.90	2.10
8 : 0	3.30	2.23
10 : 0	9.40	3.09
12 : 0	5.50	4.51
14 : 0	13.30	12.09
14 : 1	2.30	—
15 : 0 (?)	0.90	—
16 : 0	23.30	28.29
16 : 1	2.70	—
18 : 0	5.90	9.53
18 : 1	20.70	25.83
Unidentified	0.31	—

1. Per cent of total free fatty acids computed from the average of two samples analysed.
2. Per cent of total free fatty acids and computed as per Bills and Day[15].

* Acetate content is estimated from the average of the data in Table 2 as per Bills and Day[15].

esters and fatty alcohols have been shown to have strong impact on flavour even in trace amounts.

Computation of the absolute values of each of the fatty acids is difficult because the recorder response is not linear with respect to the weight of different esters[14]. However, an approximate idea of the occurrence of each of the free fatty acids in relation to the total fatty acids may be obtained by comparing the areas of the major peaks[15]. It is interesting that the C_{10} appears both at 100° and 210°C and that the area corresponding to this peak is comparable at the two temperatures. Thus C_{10} serves as an internal standard against which the relative amounts may be compared. In Table 2 average percentages of each of the fatty acids expressed as per cent of total fatty acids (4.0–18:1) are given along with values for Cheddar cheese flavour computed from the published data presented by Bills and Day[15]. With the exception of acetate, the lipolysed cream had all the major fatty acids reported for Cheddar cheese. Even the relative proportions of most of these fatty acids are comparable with the exception of C_2, C_{10} and probably C_{18}. Furthermore, lipolysed cream showed some additional fatty acids not reported for Cheddar cheese such as C_5, $C_{14:1}$, C_{15} (?) and $C_{16:1}$. Contribution of these fatty acids to the total flavour impact of the lipolysed cream has not been assessed.

Discussion

It has been suggested that a good cheesy flavour results from a judicious blend of different fatty acids in right proportions[4,18]. For instance, higher concentrations of fatty acids of C_{10}, C_{12} and C_{14} range would result in a cheese with rancid flavour[17]. On the other hand, lower fatty acids i.e. volatile fraction and their derivatives impart an "aroma" to the cheese[15,19]. Role of higher fatty acids in the overall flavour profile of the cheese is not known but is generally believed to provide the background[15] or a "backbone"[20] to the cheese flavour.

Relative proportion of individual fatty acids in the fermented cream compare very well with those reported for Cheddar cheese flavour[1,15,18]. However, there are some basic differences. For instance, Cheddar cheese flavour contains fairly large amount of acetate not found in the fermented cream. Acetate is very important for the overall flavour impact in Cheddar cheese and the best flavoured cheeses have been shown to contain a ratio of FFA to acetic acid between 0.5–1.0[18]. In normal cheese ripening, acetate may appear through the breakdown of fatty acids or as a product of carbohydrate metabolism of microoraganisms introduced through milk or as a mixed starter[18–20]. In the present process, fatty acids originate directly through lipolytic degradation of milk fat which in itself has extremely low levels of acetate[21]. Another difference between the fermented cream and Cheddar cheese flavour is the presence of a number of unsaturated fatty acids in cream which are probably derived from lipolysis of milk fat[21]. In the ripened cheese many of the unsaturated fatty acids, particularly $C_{14:1}$ and $C_{16:1}$ may undergo further transformation through metabolic activity of the bacterial starters and hence, may not appear as such in the final product[2].

The process therefore produces a flavour considered to be cheesy but not associated with any conventional cheeses for the obvious reason that a number of other flavour/taste compounds originating from lactones, amines, amino acids or carbohydrates are missing[1–5]. It is possible to improve the flavour of fermented cream to the level comparable with that of Cheddar cheese by addition of acetate so as to give the ratio of FFA (C_4-C_{18}) to acetate equivalent to about 0.5–1.0[18]. We have used the fermented cream as a flavour additive in preparation of the processed cheese using freshly rennetted curd from standardised or skim milk[11]. In such a process, cream is added to replace the fat component of the cheese to a level of 5 to 8 per cent depending on the intensity of the flavour desired in the final product. A flow sheet for the process is given in Fig 5. The cheese prepared by this method had an excellent aroma but still lacked the structure and the taste of the final cheese prepared by the

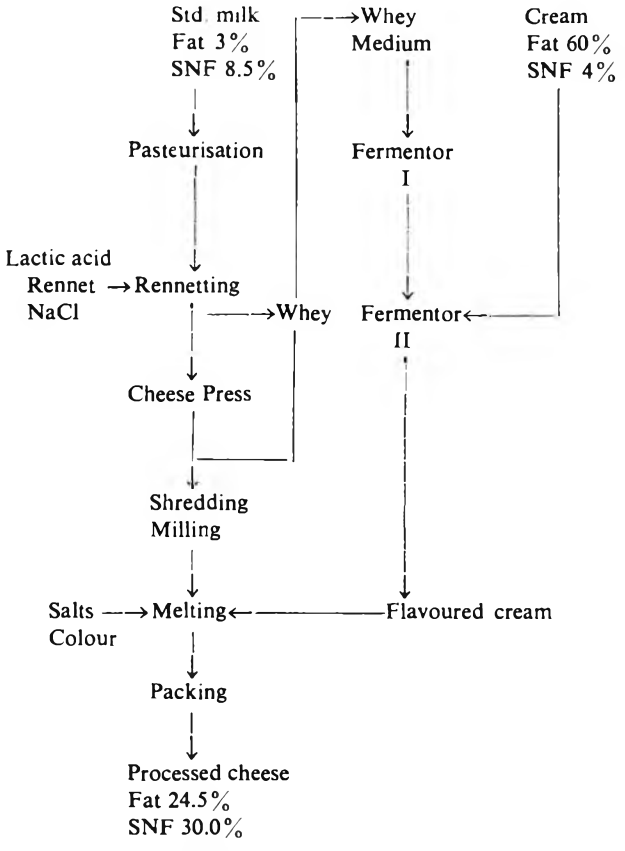


Fig 5. Flow-sheet for the preparation of processed cheese using fermented cream.

conventional process. To some extent this was expected since in a conventional ripening process, the casein of the curd undergoes a number of transformations due to the proteolytic action of the microorganisms. This problem could be circumvented to a large extent by using short ripened cheese curds in the process. The flavoured cream can be used in a number of other products such as cheese spreads, bakery fats for biscuits and cheese powdered where a cheesy flavour is desired.

Acknowledgement

Authors wish to thank Mrs S. A. Ranadive and Mr P. C. Vasavada for technical assistance, Mr H. P. Toolens of Unilever N. V. and Dr K. K. G. Menon, for many helpful discussions and Dr S. Varadarajan, earlier Director of Research for encouraging this work.

References

1. Day, E. A., in *Chemistry and Physiology of Flavours*, Schultz, H. W , Day, E. A. and Libby, L. M., The AVI Publishing Co., 1967, 331.
2. Schormuller, J., *Adv. Fd Res.*, 1968, **16**, 231.
3. Harper, W. J. and Kristoffersen, T., *J. Dairy Sci.*, 1956, **39**, 1773.
4. Harper W. J., *J. Dairy Sci.*, 1959, **42**, 207.
5. Mulder H., *Netherlands Milk Dairy J.*, 1952, **6**, 157.
6. Lawrence, R. C., *Dairy Sci Abstr.*, 1967, **29**, 1.
7. Lawrence, R. C., *Dairy Sci Abstr.* 1967, **29**, 59.
8. Arnold, R. G., Shahani, K. M. and Dwivedi, B. K., *J. Dairy Sci.*, 1975, **58**, 1127.
9. Dwivedi, B. K., *Crit. Rev. Fd Technol.*, 1973, **3**, 457.
10. Kalle, G. P., Gadkari S. V. and Deshpande S. Y., *Indian J. Biochem. Biophys.*, 1972, **9**, 171.
11. Lashkari (Mrs.) B. Z., Indian Pat No. 97096-1964.
12. Frankel, E. N. and Tarassak N. P., *J. Dairy Sci.*, 1955, **38**, 751.
13. Lowry, O. H., Rosenbrough, N. J., Farr, A. L. and Randar, R. J., *J. biol. Chem.*, 1951, **193**, 265.
14. Bills D. D., Khatri L. L. and Day E. A., *J. Dairy Sci.*, 1963, **46**, 1342.
15. Bills, D. D. and Day, E. A., *J. Dairy Sci.*, 1964, **47**, 733.
16. Ali, L.A.M. and Mulder, H., *Netherlands Milk Dairy J.*, 1961, **15**, 377.
17. Mabbitt, L. A., *J. Dairy Res.*, 1955, **22**, 224.
18. Ohren, J. A. and Tuckey, S. L., *J. Dairy Sci.*, 1969, **52**, 598.
19. Palton, S., *J. Dairy Sci.*, 1963, **46**, 856.
20. Petersen, M. H., Johnson, M. J., and Price, W. V., *J. Dairy Sci.*, 1949, **32**, 862.
21. Jensen, R. G., Quinn, J. G., Carpenter, D. L. and Sampugna, J., *J. Dairy Sci.*, 1967, **50**, 119.

Effect of Pre-and Post-harvest Treatments to Control Some Common Disorders in *Anab-e-Shahi* Grapes (*Vitis vinifera* Linn)

O. P. BEERH*, G. V. KRISHNAMURTHY, P. NARASIMHAM*, N. GIRIDHAR AND B. RAGHURAMAIAH
CFTRI Experiment Station, Hyderabad.

Manuscript Received: 29 *January* 1976

Effects of pre-harvest treatments with 0.2% Captan; 100 ppm NAA; 0.2% Captan + 100 ppm NAA in water and Waxol; 250 ppm each of Benlate and Tecto and 250 ppm Benlate + 100 ppm NAA and post-harvest treatments by fumigation with sulphur dioxide in the form of inpackage fumigant and fumes were studied during storage of *Anab-e-Shahi* grapes in the middle and late season harvests. These studies revealed that disorders like decay and berry drop were more in the late season than in the middle season harvests. The treatments did not show appreciable effect on physiological loss in weight. Treatment with in-package fumigant (IPF) proved to be the best in reducing decay, berry drop, and in retention of freshness of bunches and fallen berries. Compared to 3 days in Control, IPF extended storage life of grapes to 7 days even in late season harvest and therefore highly beneficial in commercial marketing of grapes over long distances for better returns. Fumigation with sulphur dioxide gave the next best result giving storage life of 7 days but only in middle season harvest.

Spoilage of grapes due to decay, berry drop and physiological loss in weight (PLW) are known to be some common disorders in grapes. These seriously affect the quality of grapes in storage and transportation and thereby bring down the acceptability of the fruit. Decay may occur due to incepient infection from fields or packaging materials. The dropped berries rapidly lose their marketability due to discolouration of the steam-end portion, followed by spoilage. Excessive PLW leads to shrivelling of berries. *Anab-e-Shahi* grapes too suffer from similar disorders. Andhra Pradesh has the largest area (2,874 acres) under this variety and these grapes are recognized as one of the best table varieties. There is tremendous scope of marketing this variety over long distances. But it is not possible due to severe disorders. The losses due to these disorders were estimated at 20-30 per cent during a Survey[1] carried out on post-harvest problems of grapes. Earlier, attempts to control these disorders have been partially successful. Narasimham *et al.*[2] have reported the effect of growth regulators like PCPA, NAA and GA to check berry drop in Bangalore blue grapes. Trials on storage of table grapes have been reported by Payan[3] and Jasa *et al*[4]. Control of decay in *Anab-e-Shahi* grapes with pre-harvest sprays of Captan and sodium orthophenylphenate was reported by Narasimham *et al.*[5] and berry drop by Rao *et al*[6].

The present studies were conducted in order to investigate the effect of some pre-and post-harvest treatments to control storage disorders in *Anab-e-Shahi* grapes under field conditions.

Materials and Methods

Healthy orchards having 4 to 5 years old vines were selected around Hyderabad, Andhra Pradesh. Studies were conducted on the middle and late season crops of 1973. The grape orchard was divided into randomised block design for different treatments.

Nearly 300 to 400 bunches having almost the same maturity were selected and used for various treatments, after removal of spoiled and shrivelled berries. Treatments with 100 ppm NAA, 0.2 per cent Captan, 250 ppm each of Benlate and Tecto, all dissolved in water, and with 0.2 per cent Captan + 100 ppm NAA dissolved in water as well as Waxol-O, were given as pre-harvest sprays 3 days before the scheduled harvest day. Grapes with pre-harvest treatments and those meant for post-harvest treatments like sulphur dioxide and in-package fumigation and control were harvested by clipping the bunches and packed in the vineyards in split bamboo baskets with paper shreds as packing material, conventionally used by the traders. In each basket, 5 kg of grapes were packed. For sulphur dioxide fumigation, the grapes were exposed to 0.5 per cent sulphur dioxide fumes in a closed chamber for half an hour before packing into baskets in middle season harvest (MSH)

**Present address:* CFTRI, Mysore-13.

and after packing into baskets in late season harvest (LSH). For the purpose of in-package fumigation (IPF) potassium metabisulphite in combination with citric acid (1 per cent) was packed at the rate of one gram per kg of grapes in a cloth bag of 4×4 cm size and placed in the centre of the baskets, mixed with paper shreds. During LSH, treatment with 100 ppm NAA, Captan+NAA in Waxol were dropped and treatment with 250 ppm Benlate+100 ppm NAA in water was introduced in place of treatment with Benlate alone as a pre-harvest spray.

Grape baskets were stored at RT varying from 21 to 37°C at MSH and 25-39°C in LSH. RH varied from 40 to 70 per cent in MSH and 30 to 76 per cent in LSH during the period of storage. Periodical observations were taken on five replicates in each treatment. PLW was determined by the difference in weight of filled baskets immediately after packing and at periodical intervals. Berry-drop, decay and general marketability were assessed after opening the baskets. The results are expressed as mean of five replicates and statistical significance was worked out. The consumer acceptability of grapes of treated and control lots was assessed by a panel of judges on 5 point hedonic scale: 5-very good, 4-good, 3-satisfactory, 2-poor and 1-bad. For analysis, berries were collected from the base, middle and tip of four bunches from all the four directions, pooled and used for analysis.

Results and Discussion

It is well known that as the grape season advances, the post-harvest storage life of grapes decreases with the result that grapes from the late season are hardly sent to outstation destinations as they cannot sustain the transit period. In order to see the effect of different treatmentst rials were conducted on *Anab-e-Shahi* grapes of MSH and LSH.

Effect on physiological loss in weight: Physiological loss in weight (PLW) of grapes of MSH treated in different ways is given in Table 1. The PLW ranged between 2.8 and 13.2 per cent over a storage period of 13 days. Grapes treated with Captan+NAA and NAA alone in water showed a little reduction and those treated with Tecto and Benlate, a slight increase in PLW, over the Control samples. Grapes of LSH showed almost the same pattern of PLW being nearly 1 per cent on each day of storage over a period of 10 days. In-package fumigation showed a PLW of 3.2, 4.9 and 6.8 per cent on 3, 5 and 7 days of storage, respectively. On the whole, the various treatments including those with Waxol did not show any significant effect on PLW.

Effect on berry drop: Tables 2 and 3 show the effect of various treatments on berry drop (BD) during storage of grapes of the two harvests. In MSH, berry drop was

TABLE 1. PHYSIOLOGICAL LOSS IN WEIGHT IN *Anab-e-Shahi* GRAPES OF MIDDLE SEASON HARVEST WITH VARIOUS TREATMENTS

Treatment	Physiological loss in wt (%) at indicated number of days after harvest				
	3	5	7	11	13
0.2% Captan in water	2.9	5.1	6.3	9.8	13.2
100 ppm NAA in water	2.9	5.2	6.6	10.1	12.4
0.2% Captan+100 ppm NAA in water	2.7	4.8	6.2	9.5	11.8
0.2% Captan+100 ppm NAA in 4% Waxol	2.7	4.8	6.1	9.2	11.2
SO_2 fumigation	3.0	5.1	6.6	9.2	11.8
250 ppm Benlate in water	3.1	5.3	6.8	10.9	—
250 ppm Tecto in water	3.2	5.6	6.8	11.0	—
Control	3.0	5.1	6.6	9.6	11.8
S. Em.	0.13	0.13	0.17	0.37	0.67
C.D. at 5%	—	0.39	0.49	1.06	—
C.D. at 1%	—	0.52	—	1.42	—

8-10 per cent upto 11 days but sharply rose to 18.7 per cent at 13 days of storage in Control samples. Out of all the treatments, sulphur dioxide fumigation gave the best results in controlling berry drop, which was only 2.8 to 5.7 per cent over the entire storage period of 13 days whereas in Control samples it was 10 per cent even after 3 days storage. The reduction in BD was highly significant being 74.0, 61.6 and 79.3 per cent over Control lots after 3, 5 and 7 days of storage respectively. The next best treatment to control berry drop was Captan+NAA in water, the effect of NAA having been enhanced when mixed with Captan. Here too, the reduction was highly

TABLE 2. BERRY DROP IN *Anab-e-Shahi* GRAPES OF MIDDLE SEASON HARVEST WITH VARIOUS TREATMENTS

Treatment	Berry drop (%) at indicated number of days after harvest				
	3	5	7	11	13
0.2% Captan in water	5.9	7.4	5.6	5.8	7.7
100 ppm NAA in water	6.1	6.8	6.5	5.5	5.8
0.2% Captan+100 ppm NAA in water	5.0	3.7	6.9	5.0	7.8
0.2% Captan+100 ppm NAA in 4% Waxol	6.3	5.4	11.0	8.2	12.4
SO_2 fumigation	2.8	4.1	1.7	5.0	5.7
250 ppm Benlate in water	9.4	6.2	7.9	9.9	—
250 ppm Tecto in water	7.7	5.9	5.9	7.7	—
Control	10.0	10.7	8.2	9.4	18.7
S. Em.	1.14	0.98	1.18	1.33	1.42
C.D. at 5%	3.30	2.83	3.41	—	4.24
C.D. at 1%	4.45	3.82	4.60	—	5.78

TABLE 3. PERCENTAGE BERRY DROP IN *Anab-e-Shahi* GRAPES OF LATE SEASON HARVEST WITH VARIOUS TREATMENTS

Treatment	Number of days after harvest				
	3	5	7	8	10
0.2% Captan in water	12.2	13.0	19.1	12.1	16.1
0.2% Captan+100 ppm NAA in water	6.1	5.5	10.0	7.2	10.4
250 ppm Benlate+100 ppm NAA in water	5.5	6.9	5.8	8.0	8.7
Control	10.6	15.2	17.3	12.3	19.4
SO_2 fumigation	8.1	7.7	11.7	21.4	16.1
Inpackage fumigation	6.3	5.2	7.2	—	—
S. Em.	1.57	1.75	1.75	2.70	2.40
C.D. at 5%	4.63	5.16	5.16	8.09	7.19
C.D. at 1%	—	7.04	7.03	11.15	—

TABLE 4. DECAY IN *Anab-e-Shahi* GRAPES OF MIDDLE SEASON HARVEST WITH VARIOUS TREATMENTS

Treatment	Decay (%) at indicated Number of days after harvest				
	3	5	7	11	13
0.2% Captan in water	3.2	3.6	6.5	16.1	28.2
100 ppm NAA in water	5.1	8.8	8.0	14.2	22.3
0.2% Captan+100 ppm NAA in water	2.6	5.1	10.4	17.8	27.6
0.2% Captan+100 ppm NAA in 4% Waxol	3.1	7.1	14.5	19.9	27.4
SO_2 fumigation	1.0	3.9	4.5	12.9	21.4
250 ppm Benlate in water	2.7	6.5	7.9	27.6	—
250 ppm Tecto in water	3.0	9.0	8.9	17.0	—
Control	4.1	10.3	9.8	24.0	35.5
S. Em.	0.18	1.29	0.17	3.69	2.61
C.D. at 5%	0.52	3.74	0.34	—	7.71
C.D. at 1%	0.70	5.04	0.46	—	—

significant as compared to Control over most of the storage periods. The effect of Captan + NAA was reduced when it was applied in 4 per cent Waxol solution as compared to that in water. After seven days storage, the berry drop was mostly due to stem-end rot of berries. Sulphur dioxide fumigation was helpful in reducing decay and berry drop.

In LSH, berry drop was more being 10.6 to 19.4 per cent over a storage period of 10 days as compared to 8-10 per cent in MSH for nearly the same storage period. All the treatments except one with 0.2 per cent Captan showed significant decrease in BD over a storage period of 7 days in LSH grapes. In the case of IPF the reduction was highly significant on 5 and 7 days storage, being 65.8 and 59.4 per cent respectively and

TABLE 5. DECAY IN *Anab-e-Shahi* GRAPES OF LATE SEASON HARVEST WITH VARIOUS TREATMENTS

Treatment	Decay (%) at indicated number of days after harvest				
	3	5	7	8	10
0.2% Captan in water	7.2	12.6	20.7	29.3	30.2
0.2% Captan+100 ppm NAA in water	4.3	9.7	14.3	14.4	30.5
250 ppm Benlate+100 ppm NAA in water	7.4	10.9	12.5	19.5	24.7
Control	9.4	18.2	33.2	32.3	53.6
SO_2 fumigation	5.7	8.9	21.8	34.7	39.7
Inpackage fumigation	2.5	4.8	9.7	—	—
S. Em.	1.37	1.89	2.99	5.00	6.12
C.D. at 5%	3.98	5.57	8.81	13.11	18.35
C.D. at 1%	—	7.6	12.01	—	—

43.4 per cent on 3 days storage. Sulphur dioxide treated grapes showed increased BD after 7 days storage, ranging from 11.7 to 21.4 per cent.

Effect on decay: Effect of various treatments on the incidence of decay in grapes of MSH and LSH are given in Tables 4 and 5. Decay was much greater in LSH as compared to that of MSH. In Control lot, the decay was 4 to 10 per cent over a storage period of 7 days which increased to 35.5 per cent over 13 days storage in MSH as compared to 9.4 to 33.2 per cent over 7 days and 53.6 per cent at 10 days of storage in LSH.

In MSH, sulphur dioxide fumigation showed least decay, ranging from 1.0 to 4.5 per cent over seven days storage, resulting in 73.9, 62.0 and 68.1 per cent reduction on 3, 5 and 7 days respectively which was highly significant over Control. The next best treatments were with 0.2 per cent Captan, Captan+NAA and Benlate.

In LSH, in-package fumigation gave best results as compared to all other treatments and decay was lowest being 2.5 to 9.7 per cent, throughout the storage period of 7 days for which the samples were examined. The reduction in decay in this treatment over the control was significant at 3 days and highly significant at 5 and 7 days storage and was to the extent of 73.4, 73.6 and 70.8 per cent, respectively. Treatments with Captan+NAA followed by Benlate+NAA were the next best in reducing spoilage. Sulphur dioxide treatment did not give as good results in LSH as in MSH and spoilage ranged between 5.7 and 21.8 per cent over 7 days storage as compared to 2.5 and 9.7 per cent in the case of IPF. Sulphur dioxide fumigation does not appear to be effective when grapes are rather over ripe as in LSH.

Effect on general marketability of grapes: Besides spoilage, the overall appearance of grapes has a marked effect on the consumer acceptability. Waxol treatment did not show any advantage and on the contrary, it gave

poorer appearance to the berries on account of small dark spots at the tip of the berries due to the deposition of Waxol by dripping down. Shrivelling became apparant after 11 days of storage with PLW rising to 20 per cent. The decay was mostly due to black sooty and white cottony moulds. The over all appearance of the pack was adversely affected when spoilage went beyond 7-8 per cent. This condition was reached after five days in MSH and three days in LSH. The black spores were then spread all over, even on the good berries, giving a poor appearance. This happened in all the treatments except those in IPF and to a lesser extent in sulphur dioxide treatment upto seven days in MSH and five days in LSH. Grapes with IPF were practically free from this type of spoilage even upto 7 days in LSH and hence gave a much cleaner appearance and freshness to the grapes. The green colour of rachis and pedicles which is taken as criterion for freshness by the traders, was also retained much better in IPF than in Control or any other treatment except in sulphuri doxide fumigated where it was retained only to a limited extent. The dropped berries did not show any discolouration in IPF treatment and, therefore, their freshness was comparable to those on bunches. In all the rest of treatments, dropped berries discoloured badly at stem-end portion. From the organoleptic point of view, none of the treatments showed any distinguishable differences in taste and flavour over the Control lots. At the beginning of storage, in various treatments the TSS varied from 13.6 to 16.2 per cent, total sugars from 11.66 to 14.61 per cent and acidity from 0.28 to 0.33 per cent. No significant differences were noticed during storage probably because of variations in the composition of berries from different bunches.

Conclusion: These studies showed that the overall quality of the Control grapes was considerably reduced after 3 days storage; IPF gave best results to reduce incidence of decay and BD, the two major disorders. In various replicates the maximum recorded values for decay in IPF treatment were 3.3 and 8.1 per cent as compared to maximum values of 15.2 and 23.8 per cent in the Control over 3 and 5 days storage respectively. In yet another set of experiments, carried out in a similar way on replicates to see the effect of position of IPF packet in grape baskets, decay and B.D. were sign ficantly less in IPF treatment than Control, the mean values for decay being 3.5, 5.6 and 7.1 per cent and B.D. 4.3, 4.5 and 4.0 per cent as compared to 6.8, 10.9 and 22.6 per cent decay and 6.6, 7.2 and 10.9 per cent B.D in the Control samples over 3, 5 and 7 days storage, respectively. Placement of IPF packet at base, middle or both (keeping the total quantity of IPF same-one packet), had practically the same beneficial effect. Treatment with IPF proved equally effective in transportation trials, conducted on a small scale, (3 baskets in each, treatment and Control,) from Hyderabad to Mysore by rail.

The IPF treatment extended the storage life of grapes to 7 days even in LSH crop (sulphur dioxide was effective for the same period but only for MSH crop) and thereby would permit marketing of grapes over long distances throughout the country. Andhra Pradesh sends nearly 25000 tonnes of *Anab-e-Shahi* grapes to up-country markets. Adopting IPF treatment in commercial packings will greatly reduce losses and retain freshness of grapes. The process is convenient to handle. This also does not introduce any departure from the conventional practice of packing grapes and hence should be most useful and acceptable to the trade.

Acknowledgement

Authors express gratitude to Dr B. L. Amla, Director of the Institute and to Dr D. P. Sen, for their keen interest in these studies. Thanks are also due to Shri V. S. Govindrajan, and his gro up for their help in sensory evaluation.

References

1. Beerh, O. P. and Giridhar, N., *A survey on post-harvest problems of Anab-e-Shahi grapes*, unpulished.
2. Narasimham, P., Madalagatti Rao M., Nagaraja, N. and Anandswamy, B.. *J. Fd Sci. Technol.*, 1967, **4**, 162.
3. Payan, M., *Vigneservans*, 1972, **206**, 23.
4. Jasa, B., Kopec, K , Kandeva, R., Svejcar, V. and Postbetrgl, E., *Acta Uni. Agric. Facultas Agronom. Brn.*, 1969. **17**, 609.
5. Narasimham, P., Madalagatti Rao, M., Nagaraja, N. and Anandaswamy, B., *J. Fd Sci. Technol.*, 1968, **5**, 63.
6. Madalagatti Rao, M., Narasimham, P., Nagaraja, N. and Anandaswamy, B., *J. Fd Sci. Technol.*, 1968, **5**, 127

Chemical Composition and Cooking Characteristics of Vegetable and Grain Type Soybeans

A. K. GUPTA, MANJUSHA KAPOOR AND A. D. DEODHAR
Department of Plant Breeding and Genetics, J. N. Krishi Vishwa Vidyalaya, Jabalpur, MP

Manuscript Received: 13 *November* 1975

Eight vegetable and four grain type varieties of soybeans were analysed for proximate composition, minerals (Ca, Mg, K, Zn, Cu, Fe and Mn), fatty acids and ascorbic acid (in 72-and 96-hr sprouted samples). The whole and dehulled beans were evaluated for their cooking quality. Vegetable type soybeans were found to be good source of protein and oil. Soybean varieties are quite rich in Ca, P, Fe and Cu. Vegetable type varieties ('Coker-240', '28-1-2' and 'Coker-stuart') appeared to be well balanced in their fatty acid profile as a whole and unsaturated fatty acid in particular. Vegetable varieties showed superiority over grain type in respect of their phytic acid levels. Vitamin C content increased with the increase in the duration of sprouting. Dehulling improved the cooking quality, this improvement was more pronounced in coker type varieties. 'Kali Tur' an indigenous variety, was found promising as it contained appreciable levels of all the components studied.

Though soybean is fairly consumed in many oriental countries, numerous attempts to introduce it in indigenous foods have not succeeded in this country because of the unpleasant beany flavour and the difficulty in cooking [1,2]. However, the vegetable varieties have been reported to be superior to grain type varieties in flavour, texture, cooking[3] and acceptability[4]; the trypsin inhibitor (TI) activity is also considerably less than the grain type varieties[5].

The improved grain type varieties of soybean have high yield potential and are being successfully cultivated in certain states of India. However, the inability of rural people to consume the beans directly in the form of flour or pulse without processing or pre-treatment, is the main drawback. It is against this background that vegetable soybeans were attempted for consumption.

The complex chemical composition of soybean is governed by hereditary and environmental factors. Although numerous studies have been conducted for determining the chemical composition of soybean, such information for vegetable soybeans is limited. Similarly, the information in respect of nutritive value and cookability of vegetable soybeans is very much wanting. The present study was, therefore, conducted to find the proximate principles, fatty acid composition, mineral composition with regard to certain trace elements, and phytic acid content. In view of the possible use of sprouted soybean, like gram, the levels of ascorbic acid in sprouted soybeans were also determined. Attempts were also made to assess the cookability of different soybean varieties.

Materials and Methods

Eight vegetable type varieties namely '288 BB 2-4-9-1' "BB 4-6-3', 'Kanrich', 'BB 22-4-4', 'Coker 240', 'Coker-stuart', 'Coker 102' and 'No. 28-1-2'; and four grain type varieties, namely 'Bragg', 'JS-2', 'Pb-1' and Kali Tur' were selected for the study.

The samples were obtained from 1974-75 field trails conducted at JNKVV Jabalpur. The samples were analysed for proximate principles, moisture content, minerals (P, Ca, K, Zn, Cu, Fe and Mn), phytic acid and cooking quality, as described below.

Proximate principles: The moisture, protein and oil were determined according to the AOAC procedure[6]. Total polysaccharides were estimated according to Hassid and Abraham[7]. The reducing and non-reducing sugars were determined by using Hane's ferricyanide method described by Browne and Zerba[8].

Mineral composition: The samples were digested with triacid mixture according to David[9]. Phosphorus (P) and potassium (K) were determined by the methods described by Jackson[10]. For the determination of calcium (Ca), 20 ml of the above extract was taken in a flask and to this, 5 ml of solution containing 3 per cent magnesium chloride and 0.75 per cent of potassium chloride was added. The readings were taken in atomic absorption spectrophotometer-AA 120 (Varian Techtron, Australia) at wave length of 4226.7Å. In order to estimate zinc, copper, iron and manganese, the extract was taken directly and the readings were taken in the atomic absorption spectrophotometer at the wave lengths of 2138.6Å, 3247.5Å, 2483.1Å and 2794.8Å respectively.

Phytic acid: This was determined according to the procedure described by Rosenbaum and Baker[11].

Fatty acids: The fatty acid analysis of soybean seed oil was done using gas chromatograph GC-4 BPTF (Daul column) as adopted by Mehta and Sen[12].

Ascorbic acid: Ascorbic acid content was determined at 72 and 96 hr in sprouted soybeans according to the method of Roe and Keuther[13].

Cooking quality: The method described by Zakardas *et al.*[14] was standardised for this purpose. About 10 g of soybeans (whole and dehulled) were taken in a beaker and 100 ml of distilled water was added and cooked in an autoclave at 15 lb pressure for 90 and 75 min under different conditions. The cooked material was stirred for a minute and was passed through a 2.0 mm sieve. The fraction which remained on the sieve was washed with water (100 ml) and two fractions (one that passed and the other that did not pass) were dried to constant weight at 100°C. The ratio of the weight of the fraction which passed through the sieve to the total weight of both the fractions expressed as percentage was adopted as the index of cookability.

Results and Discussion

Proximate principles: It is evident from Table 1 that in the 12 varieties of soybean, the values for moisture, protein, oil, total polysaccharides and reducing and non-reducing sugars ranged from 7.6 to 9.2, 37.0 to 40.4, 17.7 to 23.0,12.7 to 15.2 and 3.8 to 5.0 per cent respectively; the average being 8.3, 38.6, 20.5, 13.8 and 4.3 per cent respectively.

The average value of 8.3 obtained for moisture compared well with those reported earlier[15].

It may be seen from Table 1 that varieties 'Coker-240' and 'JS-2' are significantly superior with respect to protein to the rest of the varieties except for variety '28-1-2'. 'Coker-stuart' and 'Coker-102' contained 38.8 and 38.6 per cent protein respectively. 'Kali Tur' however contained 38.1 per cent which is close to the average value of 38.6 per cent. Lal *et al*[16] reported that 'Pb-1' was significantly superior in protein content (41.0 per cent) and was superior to all except 'Leel' (40.2 per cent). However, in the present study, 'Pb-1' contained 38.5 per cent protein and 'JS-2', a grain type and 'Coker-240', a vegetable type registered higher value for protein content as compared to 'Pb-1'.

This difference could be attributed to the effect of environment. Furthermore, Lal *et al*[16] reported the average protein content observed at different locations while the present values are restricted to one location.

Barring 'JS-2', the other grain types have indicated lower protein content as compared to vegetable types. It is thus evident that vegetable type soybeans, constitute equally good source of protein and thus help in alleviating the protein deficiency.

There is no distinction between the grain and vegetable type varieties in respect of their oil content. The Coker type varieties viz, 'Coker-102', 'Coker 240' and 'Coker-stuart' have registered an oil content of 19.8, 20.6 and 21.9 per cent respectively which is moderate as compared to the average value of 20.5 per cent. Location has been found to be a major factor for affecting the oil content[17].

The variety 'JS-2' which recorded significantly higher protein content (40.1 per cent) has shown the lowest value for polysaccharide content (12.7 per cent) in the present study. Further, 'Kali Tur' which contained 38.1 per cent of protein, has shown the maximum value for polysaccharide (15.2 per cent). The Coker type varieties contained significantly lower values than to that of 'Kali Tur' and higher to that of two grain types ('Pb-1' and 'JS-2') and three vegetable type varieties ('288-BB-2-4-9-1', '28-1-2' and 'BB4-6-3'). It is seen that the range of 17.6-22.5 per cent is rather low as compared to those observed by Deodhar *et al*[4].

The observed range of 3.8-5.0 per cent for reducing and non-reducing sugars is on the higher side as compared to those reported (1-4-3.0 per cent) by Deodhar *et al.*[4]

Besides, the varieties 'Coker-stuart' and 'Coker-102' are also important as they contain appreciable levels of protein and oil and relatively moderate levels of polysaccharides. The variety 'Coker-240' which contained the highest protein (40.4 per cent) and relatively moderate oil (20.6 per cent) is also very important in spite of its high polysaccharide content (15.2 per cent) as this value is also quite low when compared to the value of 20.7 as reported earlier[4].

TABLE 1. PROXIMATE COMPOSITION OF SOME VEGETABLE AND GRAIN TYPE VARIETIES OF SOYBEAN

Variety	Moisture (%)	Protein (%)	Oil (%)	Polysaccharides (%)	Sugars* (%)
288-BB 2-4-9-1	7.6	38.2	17.7	13.4	4.7
BB-4-6-3	8.0	39.2	22.4	12.4	4.6
Kanrich	8.2	38.1	23.0	14.1	3.5
BB 22-4-4	8.2	37.0	19.5	14.5	3.8
Coker-240	7.6	40.4	20.6	14.7	3.9
Coker-102	8.5	38.5	19.8	14.1	4.8
Coker-stuart	7.8	38.8	21.9	14.6	5.0
28-1-2	8.7	39.5	18.9	13.2	4.2
Bragg	8.7	37.1	21.6	14.3	4.7
JS-2	8.2	40.1	21.3	12.4	4.4
Pb-1	9.2	38.6	20.5	13.1	3.9
Kali Tur	8.8	38.1	18.1	15.2	4.7
Mean	8.3	38.6	20.5	13.8	4.3
S.Em. (V)	—	0.23	—	0.17	0.19
C.D. (5%)	—	0.71	—	0.49	0.59
C.D. (1%)	—	1.01	—	0.68	0.83

*Reducing + non-reducing

TABLE 2. MINERAL COMPOSITION AND PHYTIC ACID CONTENT OF SOYABEAN VARIETIES

Variety	Calcium (Ca)	Phosphorus (P)	Potassium (K)	Zinc (Zn)	Copper (Cu)	Iron (Fe)	Manganese (Mn)	Phytic acid (%)
	←——g/100g——→			←——mg/100g——→				
288-BB 2-4-9-1	0 40	0 58	1 25	4 24	2 00	7 0	3 16	4 84
BB 4-6-3	0 35	0 70	1 30	3 87	2 00	9 0	3 50	4 34
Kanrich	0 35	0 63	1 30	4 25	2 00	8 0	3 33	4 26
BB 22-4-4	0 38	0 73	1 35	4 12	2 00	10 0	3 16	4 32
Coker 240	0 32	0 41	1.15	3.87	1.83	11.0	3.16	3.79
Coker 102	0.38	0.52	1.25	3.87	2.20	8.0	3.33	4.20
Coker-stuart	0.44	0.45	1.02	4.12	1.83	9.0	3.83	4.06
28-1-2	0.40	0.86	1.50	3.87	2.16	9.0	4.66	4.22
Bragg	0.39	0.57	1.15	4.37	2.00	9.3	2.82	3.87
JS-2	0.43	0.62	1.15	4.12	1.66	6.7	3.00	3.49
Pb-1	0.39	0 50	1 15	4 62	1 33	14 0	3 66	3.78
Kali Tur	0.31	0.59	0.90	3.75	1.83	8.0	2.16	3.12
Mean	0.38	0.596	1.20	4.08	1.90	9.08	3.31	4.02
S.Em. (V)	—	—	—	—	—	—	—	0.20
C.D. (5%)	—	—	—	—	—	—	—	0.62

Mineral composition: It is evident from the data (Table 2) that calcium, phosphorus and potassium are principal mineral components and their values (g/100g) ranged from 0.311 to 0.437, 0.407 to 0.855 and 0.900 to 1.50 respectively. These values obtained are in close agreement with those values reported by others[18-19].

Soybeans-both vegetable and grain types are source of Ca and P as the observed values are higher than those reported in cereals, millets, pulses and oil seeds[15].

The values for Zn, Cu, Fe and Mn varied from 3.75 to 4.62, 1.33 to 2.20, 6.66 to 14.00 and 2.16 to 4.66, mg/100 g of seeds respectively (Table 3). Copper and iron contents are remarkably higher than those reported by Gopalan *et al.*[15] for cereals, millets, pulses and oil seeds. The observed average value of 9.08 mg/100 g dry seeds for iron content closely resembles with the value of 11.5 mg/100 g of dry seeds as reported by Aykroyd[19].

TABLE 3. FATTY ACID COMPOSITION (PER CENT) OF SOYBEAN SEED OIL

Variety	Palmitic 16:0	Stearic 18:0	Oleic 18:1	Linoleic 18:2	Linoleic 18:3
Coker 240	11.5	5.0	33.5	44.7	5.3
Coker-stuart	13.0	5.6	25.7	49.1	6.6
28-1-2	10.9	4.8	30.9	48.1	5.3
Bragg	11.8	5.3	24.4	52.4	6.1
JS-2	11.2	5.5	34.8	44.0	4.5
Pb-1	10.7	3.8	37.2	43.7	4.6
Kali Tur	10.5	4.1	23.0	55.1	7.4
Mean	11.3	4.8	29.9	48.1	5.6

It can be concluded that soybean has remarkably higher Ca, P, K, Cu and Fe content than many of the foodstuffs.

No apparent demarcation could be made between vegetable and grain type varieties of soybean as regards the contents of these nutrients.

Phytic acid: The phytin present in soybean is the calcium-magnesium-potassium salt of phytic acid[20]. The phytates are important because of their effect on protein solubility, availability of calcium and cookability[21].

It is observed (Table 2) that the phytic acid varied from 3.12 to 4.84 per cent. The mean value being 4.02 per cent. No significant differences were observed amongst the vegetable type varieties in respect of their phytic acid content at 1 per cent level of probability. O'Dell and Savage[22] reported that the phytic acid content in soybean is around 0.5 per cent and perhaps is bound to trace elements.

Although the varietal differences were significant as regards cookability (Table 5), there was no concomitant differences in the phytic acid contents (Table 2). This is in contrast to the observations made by Rosenbaum *et al.*[23] in peas. But later on Rosenbaum and Baker[11] suggested that the higher cookability of the interior portion of cotyledons of peas was not associated with the higher phytic acid content. Therefore, in soybeans, the cookability may be governed by the interaction of factors like seed coat, seed size, and the contents of phytic acid, calcium, magnesium, pectins, etc.

Fatty acids profile: It is seen from Table 3 that the fatty acid composition of soybean oil ranged as follows.

Palmitic acid, 10.5–13.0; stearic acid, 8–3.5.6; oleic acid, 23.0–37.2; linoleic acid, 43.7–55.1 and linolenic acid, 4.5–7.4 per cent. These values are in agreement with those reported by Schuster[24] except for linolenic acid where the values are low. The low content of linolenic acid in Indian soybeans has also been reported earlier by several workers[4,24,27].

Linoleic acid is the major fatty acid of soybean as evident from Table 3. This is in agreement with the findings of earlier workers[4,24].

In the present study, the 'Kali Tur' contained highest level of linoleic acid (55.10 per cent) followed by 'Bragg' (52.4 per cent), 'Coker-stuart' (49.1 per cent), '28–1–2' (48.1 per cent) 'Coker-240' (44.7 per cent), 'JS-2' (44.0 per cent) and 'Pb-1' (43.7 per cent).

Greater variation was observed with respect to unsaturated fatty acid contents (11.4, 14.2 and 2.9 per cent for linoleic, oleic and linolenic acid respectively) than the saturated fatty acid contents (2.5 for palmitic acid and 1.8 per cent for stearic acid). This variation may be attributed to the soil, season, location and temperature changes during seed maturity as observed by others.

The vegetable type varieties (Coker-240', '28–1–2' and 'Coker-stuart') appear to be well balanced both in their fatty acids and unsaturated fatty acids profiles. The two grain type ('Bragg' and 'Kali Tur') which exhibited relatively higher concentrations of linoleic acid are showing lower levels of oleic acid which is in contrast to the other two grain type varieties ('Pb–1' and 'JS–2').

Ascorbic acid content of sprouted soybeans: The ascorbic acid content of sprouted soybeans has widely varied from 2.35 to 42.48 mg/100 g (Table 4). In 'Pb–1', 'Kanrich', 'Coker-102' and 'Coker-stuart' varieties, the ascorbic acid content decreased at 96 hr of sprouting as compared with the levels at 72 hr of sprouting. However, in the remaining varieties the ascorbic acid levels have shown marked increase.

The variety 'Kali Tur' has shown significantly higher content of ascorbic acid at 72 hr of sprouting (16.0 mg/100 g of seeds) than other varieties and this value has more than doubled at 96 hr of sprouting. Amongst 72–hr sprouted beans, the varieties like 'Pb–1', 'BB–4–6–3' and 'Kanrich' have followed 'Kali Tur' in ascorbic acid content and the values are significantly higher than the remaining varieties. Coker type varieties showed quite low ascorbic acid levels as compared to other varieties. The ascrobic acid content of vegetable type varieties has ranged from 2.35 to 12.32 mg/100 g of seeds at 72 hr of sprouting and from 3.90 to 14.65 mg/100 g of seeds at 96 hr of sprouting.

Cooking quality: The cookability of whole and dehulled beans varied from 25.8 to 46.0 and 34.4 to 52.0 per cent respectively (Table 5). The cookability increased in all the varieties when the seed coat was removed; the percentage increase over the whole beans being 54 to 71.2 with an average of 41.2.

The whole beans of Coker type varieties ('Coker-stuart', 'Coker-102' and 'Coker-240') have shown significantly lower cookability than the other vegetable types like '288 BB 2–4–9–1', 'Kanrich' and 'BB 4–6–3' at 1 per cent level of probability. But after dehulling, the cookability of 'Coker-stuart', 'Coker-102' and

TABLE 4. ASCORBIC ACID CONTENT OF SPROUTED SOYBEAN VARIETIES

Variety	72-hr sprouting (mg/100g)	96-hr sprouting (mg/100g)
288 BB 2-4-9-1	4.74	9.18
BB 4-6-3	12.32	14.65
Kanrich	10.54	7.15
BB 22-4-4	3.95	12.29
Coker-240	2.35	3.90
Coker-102	6.34	4.77
Coker-stuart	4.69	4.34
28-1-2	5.70	7.48
Bragg	6.66	7.57
JS-2	5.51	8.25
Pb-1	12.76	10.14
Kali Tur	16.01	42.48
Mean	7.63	11.10
S.Em. (V)	1.10	—
C.D. (5%)	3.06	—
C.D. (1%)	3.98	—

TABLE 5. COOKING QUALITY OF SOME VEGETABLE AND GRAIN TYPE SOYBEANS

Variety	Cookability		
	Whole beans (%)	Dehulled beans (%)	(%) increase in cookability
288 BB 2-4-9-1	46.1	48.6	5.4
BB 4-6-3	35.9	39.3	9.6
Kanrich	37.1	46.2	24.5
BB 22-4-4	29.6	44.2	49.3
Coker-240	27.8	47.6	71.3
Coker-102	25.8	42.3	63.9
Coker stuart	28.6	36.7	28.3
28-1-2	31.3	52.7	68.3
Bragg	31.3	41.7	33.2
JS-2	36.3	57.1	57.3
Pb-1	30.4	48.8	60.5
Kali Tur	31.3	38.7	23.6
Mean	32.5	45.3	41.2
S.Em. (V)	1.3	1.1	
C.D. (5%)	3.8	3.3	
C.D. (1%)	7.0	6.2	

'Coker-240' increased by 28.3, 63.9 and 71.2 per cent respectively.

The dehulled beans of two varieties ('28-1-2' and 'Pb-1') showed significantly higher percentage of cookability ($P=0.05$) than others and the increase in cookability was 68.3 and 60.5 per cent for '28-1-2' and 'Pb-1', respectively as compared to whole beans. Therefore, the vegetable type beans may be cultivated and used extensively to overcome protein mal nutrition in the country.

Acknowledgement

The authors are thankful to Dr S. L. Mehta, and Shri K. Sen, of I.A.R.I., New Delhi for fatty acid analysis of the samples and to Dr D. P. Motiramani, Director, Research Services, for valuable suggestions and to Dr S. P. Singh of Plant Breeding and Genetics department for providing facilities and encouragement. Thanks are also due to Shri S. K. Mehta, Assistant Breeder (Soybean) for providing samples.

References

1. Kanthamani, S., *Tasty Recipes from Soybean*, Directorate of Extension and USAID, JNKVV, Jabalpur, 1970.
2. Rathod, K. L. and Williams, S. W., *Indian J. Nutr. Dietet.*, 1973, **10**, 18.
3. Morse, W. J., *Soybean and Soybean Products*, Markely, I.K.S. (Editor), John Willey and Sons, New York, 1950.
4. Deodhar, A. D., Lal, M. S., Sharma Y. K. and Mehta, S. K., *Indian J. Nutr. Dietet.*, 1973, **10**. 34.
5. Gupta, A. K. and Deodhar, A. D., *Indian J. Nutr. Dietet.*, 1975, **12**, 81.
6. *Official Methods of Analysis*, Association of Official Agricultural Chemists, Washington, D. C., 1965.
7. Hassid, W. Z. and Abraham, S., *Industr. Engng Chem., Anal. Edit.*, 1937, **9**, 288.
8. Browne, C. A. and Zerban, P. W., *Sugar Analysis*, John Willy & Sons Inc. London, III Ed, 1952, 744.
9. David, D. J., *Analyst, Lond.*, 1958, **84**, 53.
10. Jackson, M. L., *Soil Chemical Analysis*, Prentice Hall, New Delhi, 1967, 111.
11. Rosenbaum, T. M. and Baker, B. E., *J. Sci. Fd Agric.*, 1969, **20**, 709.
12. Mehta, S. L. and Sen, K., Unpublished, Nuclear Research Laboratory, I.A.R.I., New Delhi.
13. Roe, J. H. and Keuther, C. A., *J. biol. Chem.*, 1943, **169**, 999.
14. Zakardas, C. G., Henneberg, G. C. and Baker, R. E., *J. Sci. Fd Agric.*, 1965, **16**, 734.
15. Gopalan, C., Ramashastri, B. V. and Balsubramanian, S. C., *Nutritive Value of Indian Foods*. National Institute of Nutrition, Hyderabad, India, 1972.
16. Lal, M. S., Mehta, S. K., Deodhar, A. D. and Sharma, Y. K., *Indian J. agric. Sci.*, 1973, **43**, 14.
17. Crowford, D. E. and Gillingham, J. T., *Oil and Protein in South Carolina. Agric. Expt. Stn. Bull*, AE-303, 1967.
18. Pant, R. and Kapoor, A. S., *Ann. Biochem. Med.*, 1963, **11**, 257.
19. Aykroyd, W. R., Gopalan, C. and Balasubramanian, S. C., *The Nutritive Value of Indian Foods and the Planning of Satisfactory Diets*, 6 Edn, Indian Council of Medical Research, New Delhi, 1966.
20. Staley, A. E., *Phytin and Inositol-A Bibiolography*, A. E. Staley Mfg. Co; Decatur, 1952, 111.
21. Muller, F. M., *J. Sci. Fd Agric.*, 1967, **18**, 292.
22. O'Dell, B. L. and Savage, J. E., *Proc. Soc. exp. Biol. Med.*, 1960, **103**, 304.
23. Rosenbaum, T. M., Hanneberry, G. O. and Baker, B. E., *J. Sci. Fd Agric.*, 1966, **17**, 237.
24. Schuster, W., *Fette Seifen Anstr. Mittel*, 1973, **75**, 289.
25. Rao, G. K. V., Subbaram, M. R. and Achaya, K. T., *Indian J. Technol.*, 1971, **9**, 265.
26. Sekhon, K. S., Singh, T. P. and Ahuja, K. L., *Indian J. Nutr. Dietet.*, 1975, **12**, 21.
27. Schuster, W., *Fette Seifen Anstr. Mittel*, 1971, **73**, 305.

Utilization of Mango Waste: Recovery of Juice from Waste Pulp and Peel

O. P. BEERH,* B. RAGHURAMAIAH, G. V. KRISHNAMURTHY AND N. GIRIDHAR
CFTRI Experiment Station, Hyderabad

Manuscript Received: 29 *January* 1976

Juice was recovered from mango peel and waste fibrous pulp by treatment with pectic enzyme. The recovery was 75–80% from waste pulp and 51% from peel. The peel and pulp juice had 48 and 51% total sugars, respectively. This juice, when added to mango pulp and used for preparation of nectar, did not in any way alter its taste or flavour. Optimum rehydration of dried peel and pulp was worked out for efficient recovery of syrup from the dried samples. Good quality wine and vinegar were prepared from juice from fresh waste and syrups from dried waste by partial precipitation of tannins to over come undue astringency. A concentrated syrup having good taste and attractive light yellow colour was obtained from syrups by treatment with gelatin and carbon which highly improved their colour. Discolouration of concentrates during storage was checked by addition of 1000 ppm of sulphur dioxde.

The production of mango products has gone up steadily from 11,317 tonnes in 1966 to 17,847 tonnes in 1970[1]. During manufacture of mango products from ripe mangoes, large quantities of mango waste come out from the canneries, accounting for 40-60 per cent of fruit, depending on the variety. Waste comprises mostly of peel and stones, which constitutes about 15 and 18-20 per cent of the fruit, respectively. Besides this, is the waste fibrous pulp obtained, particularly, in the manufacture of mango juice or nectar. Such fibrous waste pulp is estimated to be nearly 8-10 per cent of the fruits. Disposal of such large quantities of mango waste is a serious problem for the industry. Utilisation of this waste will reduce its disposal problem and will also bring economy in the production of mango products.

Recovery of useful ingredients from cannery waste has been reported for many fruits.[2-6] Earlier work with respect to mango waste has been mostly limited to the use of mango kernel for animal feed. Pruthi *et al.*[7] have reviewed the work done with respect to mango waste utilization. Pruthi and Susheela[8] have also carried out studies on utilisation of mango kernel. The present paper describes the work carried out to recover additional quantity of juice for adding back to the main lot of mango nectar or for the manufacture of wine and vinegar from waste mango peel and fibrous pulp.

Materials and Methods

Mango peel and pulp used in these studies were procured from a local fruit processing factory. These were the discarded wastes obtained during processing of 'Totapuri' mangoes for juice and nectar. Waste consisted of fibrous pulp obtained by passing the coarse mango pulp through a finisher fitted with a fine sieve of 32 mesh size.

For recovery of juice or syrup, pectic enzyme in the liquid form supplied by CFTRI, Mysore was used. Trial lots were limited to 2-5 kg of raw material. Peel was used in the minced form and pulp as such without further mincing. Pectic enzyme was added to the raw material, mixed thoroughly and allowed at room temperature (25-35°C) for different reaction times. For the recovery of juice required for fermented products or syrup concentrate, an enzyme concentration of 0.3 to 0.8 per cent was tried with a reaction time of 24 hr coupled with addition of 100 ppm sulphur dioxide. In the other case when juice recovered from waste was required to be put back to main lot of mango juice/nectar, higher concentrations of enzyme, from 0.3 to 3.0 per cent were tried for reaction times varying from 2 to 12 hr without addition of any sulphur dioxide. After the reaction time, the peel and pulp were pressed through a cloth to get clear juice.

Drying of waste peel and fibrous pulp was done in sun and in a cross flow direr at 70-80°C with a tray load of 4 kg/m^2. Extraction of syrup from dried samples was tried by taking 100 g of dried peel and pulp and after initial rehydration with varying proportion of water, followed by addition of pectic enzyme.

The juice from fresh material and syrup from dried materials were concentrated to 72° Brix in a rotary vacuum evaporator at 62°C after different treatments. Calcium oxide and calcium carbonate were added in the form of 10 per cent slurry and pH was raised to 5.5 to neutralise excess acidity. Gelatin was added in the

*Present address: CFTRI, Mysore-13

form of 1 per cent solution to overcome undue astringency. Carbon (Hypine-a product of Hypine Carbon Ltd., Nalagarh, H.P.) was added at the rate of 2 per cent and the mixture was simmered for 10 min and later kept at RT for 1 hr. Control and treated syrups were filtered with supercell under vacuum to get clear syrup.

For the preparation of wine and vinegar, 100 ml of press out juice from peel and pulp were separately inoculated with pure strains of *Saccharomyces cerevisiae* and when this was vigourously fermenting, it was added to more quantity of respective juices. The final mixture was allowed till fermentation is completely over (10 days). Sulphur dioxide (100 ppm) was added to check the growth of undesirable micro-organisms. After settling of yeast, the wine was 'racked', filtered through supercell, bottled and pasteurized at 65°C. For the preparation of vinegar, the alcoholic ferment was mixed with mother vinegar (3:1) and the process of acetification allowed to proceed by 'let alone' method. This took 45-60 days at room temperature, varying from 25-35°C and humidity 50-80 per cent. Organoleptic quality of the products was assessed on a five point scale: 5-very good, 4-good, 3-satisfactory, 2-poor and 1-bad. Composition of peel and pulp was determined by AOAC method[9] and pectin by Carre and Hayne's method[10].

Results and Discussion

Analysis of the waste (Table 1) showed that it had nearly 48 per cent total sugars in peels and 51 per cent in the waste pulp on dry weight basis (DWB). This indicated a great potential for utilization of the waste if the sugar could be effectively recovered.

1. *Recovery of juice from peel and waste pulp:* Clear juice was recovered from peel and pulp by treatment with pectic enzyme. The quantity of pectic enzyme needed for maximum extraction of juice was assessed by using different proportions of pectic enzyme. Recovery of juice from fresh waste fibrous pulp was 75 per cent with 0.3 per cent pectic enzyme and 80 per cent with 0.6 and 0.8 per cent pectic enzyme. Thus 0.3 per cent pectic enzyme was almost sufficient to extract nearly 93 per cent of the total extractable juice. Minced peel yielded 51 per cent juice with 0.8 per cent pectic enzyme. Composition of this juice with respect to the important constituents is given in Table 2. The juice was yellowish in colour in the case of peel and faint yellow in the case of pulp. The taste of the pulp juice was pleasant and good but that of peel was slightly astringent. Astringency was found to be due to tannins and hence was overcome by treatment of juice with 1 per cent solution of gelatin. The differences in the composition of waste and juice recovered (Table 2 and 3) is due to batch to batch variation in the level of ripeness of fruits handled by the factory. For complete recovery of juice with pectic enzyme upto 0.8 per cent level, the material had to be allowed a reaction time of nearly 24 hr in which case addition of 100 ppm SO_2 became necessary to avoid fermentation. But incorporation of sulphur dioxide would be objectionable for adding back the extracted juice to the main lot of mango nectar/juice, meant for canning. In order to see the possibility of extracting the juice within a shorter span of time which would avoid use of sulphur dioxide, higher doses of pectic enzyme with shorter reaction time were tried. These trials showed that the process of liquification which facilitates pressing out of free flowing juice was completed even within a short span of 4 hr when pectic enzyme was added at 3 per cent level. This higher concentration of pectic enzyme did not make any noticeable change in the organoleptic quality of juice obtained. With a reaction time of 12 hr, even 1.5 per cent pectic enzyme was sufficient, and the juice recovered after 12 hr had a

TABLE 1. PROXIMATE COMPOSITION OF MANGO WASTE

Particulars	Peel	Waste pulp
Fresh material		
T.S.S. (°Brix)	21.0	12.5
Moisture %	68.5	83.2
pH	3.1	3.2
Dried material		
Acidity %	2.56	2.28
Sugars: Total %	48.07	51.30
Reducing %	40.76	23.86
Pectin %	12.85	10.55
Starch %	2.91	5.15
Nitrogen %	0.256	0.53
Crude fibre %	8.38	6.03
Tannins %	2.341	negligible
Ash %	2.914	2.43

TABLE 2. SOME IMPORTANT CONSTITUENTS OF JUICE RECOVERED FROM PEEL AND WASTE PULP

Particulars	Peel juice	Waste pulp juice
T.S.S. %	18.00	15.0
Sugars Reducing %	13.46	11.62
Total %	13.60	11.72
Acidity %	1.17	1.29
pH	3.5	3.1
Colour	Yellowish	Faint Yellowish
Taste	Not good, astringent and acidic	Good, acidic.

pleasant taste and characteristic mango flavour without any off flavour. The juice so recovered from waste pulp was added to mango pulp at 10 and 20 per cent level and later used for the preparation of mango nectar (20 per cent mango solids). This nectar was canned in A-1 tall cans. The cut-out results carried out after 7 days storage did not show any distinguishable change in aroma or taste of this nectar as compared to nectars from controlled lots. Thus, it is possible to get nearly 370 kg of additional mango nectar per ton of mangoes processed which will work out quite substantial on large scale processing of mangoes. During the glut in mango processing season, it may not be possible to take up waste for recovery of juice immediately and hence, drying of mango waste may become necessary. Table 3 gives the progress of drying in sun and dehydrator. Drying was completed in the dryer within a period of 12 hr bringing down the moisture to 3.5 per cent in peel and 3.8 per cent in pulp. In the case of sun drying, pulp was completely dried in three days but not the peel. The dried materials were used for recovery of syrup. Peel and pulp were rehydrated with different proportions of water before mixing with pectic enzyme. The results with respect to the recovery of syrup and TSS for peel and pulp are given in Table 4. Recovery of syrup and TSS was practically negligible with 1:1 rehydration. It was 44 per cent in 1:2, and 50 per cent in 1:3 rehydration ratio, the last being practically same as drying ratio. The syrup recovered from dried pulp and peel were brownish in colour as compared to yellowish colour in the fresh samples.

2. *Preparation of concentrated syrup from peel and pulp:* The juice recovered from fresh peel and pulp, and syrups from dried materials, were concentrated in order to get a concentrated syrup either for confectionary purposes or as covering syrup for canning mango slices. Peel juice and syrup were astringent due to presence of tannins and syrup was also brownish in colour. Before concentration, these were, therefore, given a number of treatments with a view to improve colour, eliminate astringency and reduce acidity. The results are indicated in Table 5. Calcium oxide and calcium carbonate treatments did not have the desired effect in improving the quality of syrup. Treatments with gelatin and carbon completely eliminated astringency and highly improved the colour of the syrup. Requirements of gelatin for complete precipitation of tannins was assessed on the basis of preliminary trials. Of the various brands of activated carbon studied, Hypine carbon gave very good results between a pH range of 3-4 and improved the colour considerably. After carbon treatment, the pH was raised with calcium oxide. During adjustment of pH, there was a distinct change in the colour of juice and syrup. Colour was very good being light yellow, till a pH of 4.5 but slightly deteriorated to dark yellow when pH was raised to 5.0, in the case of syrup. This adverse change in colour in the peel juice was of less importance and came only at 5.5 pH instead of 5.0. This difference was reflected in little darker colours of corresponding concentrates. In view of this, a pH of 4.5 only is recommended for syrup meant for concentration. Though gelatin and carbon treatments considerably improved the colour of peel syrup, concentrate from this was still inferior in colour to the concentrates from peel juice. In view of this it is better to use fresh peels.

TABLE 3. PROGRESS OF DRYING MANGO PEEL AND PULP IN SUN DRYING AND DEHYDRATOR

Drying time hr	Peel (kg.)	Pulp (kg.)
Sun drying		
0	4.00	4.00
24	2.75	1.75
48	1.55	0.85
72	1.40	0.75
120	1.30	0.75
Drying ratio	3.1:1	5.3:1
Moisture %	4.54	4.20
Dehydration		
0	3.00	4.00
3	1.60	1.00
10	0.85	0.75
12	0.80	0.70
Drying ratio	3.7:1	5.7:1
Moisture %	3.51	3.82

TABLE 4. RECOVERY OF SYRUP FROM DRIED SAMPLES REHYDRATED WITH DIFFERENT PROPORTIONS OF WATER

Particulars	Peel			Waste pulp				
Dried sample (g.)	100	100	100	100	100	100	100	100
Water (g.)	100	200	300	200	300	400	500	600
Pectic enzyme (g.)	3	3	3	2.4	3.2	4.0	4.8	5.6
Press out syrup (g.)	4	170	266	10	105	220	405	475
Soluble solids of syrup (%)	28	26	19	20.0	19.0	16.0	13.5	11.5
TSS recovered (g.)	1.1	44.2	50.5	2	20.0	35.2	54.7	54.6

TABLE 5. QUALITY OF PEEL JUICE AND SYRUPS RECORDED AFTER VARIOUS TREATMENTS

Treatment	Diluted syrup colour	Concentrated syrup	
		Colour	Taste
Syrup from dried peels (control)	Light brownish	Brownish	Astringent—not good
Syrup treated with calcium oxide	Light brownish	Brownish	Slightly bitter and astringent—not good.
Syrup treated with calcium carbonate.	Light brownish	Brownish	Astringent—not good.
Syrup treated with carbon	Light yellow	Slightly brownish yellow	Astringent—not good.
Syrup treated with gelatin	Yellowish	Very slightly brownish yellow	Not astringent—good.
Syrup treated with gelatin and carbon; pH 4.5	Faint yellowish tinge.	Yellowish good	Not astringent—slightly acidic—good.
Juice from fresh peel, treated with gelatin and carbon; pH 5.0	Negligible faint yellowish tinge.	Light yellow—very good.	Not astringent and not acidic—very good.

Further trials are necessary to prove whether dried peel may give equally good coloured concentrate by treatment of peels with potassium meta-bisulphite before drying. In the case of waste pulp, both juice and syrup yielded an attractive faint yellow and tasty syrup after treatment with carbon and adjustment of pH to 5 with calcium oxide. Concentrate too had attractive light yellow colour and there was practically no difference in the concentrate prepared from dried or fresh pulps.

Concentrates prepared from peel and pulp with above pre-treatments, fast deteriorated in colour after preparation, turning brown within 2-3 days at RT. Addition of ascorbic acid at the rate of 100 mg per cent during and after preparation of concentrate did not check browning. But addition of SO_2 at the rate of 1000 ppm only could check discolouration completely, over a period of 10 days for which the samples were observed. Further studies are necessary to assess the safe storage life of these concentrates.

3. *Wine and vinegar from peel and pulp syrups:* Wines were prepared from press-out juice from peel and pulp. Fermentation did not proceed well at the normal acidities of pulp (1.17 per cent) and peels (1.29 per cent). Acidity, therefore, had to be reduced to 0.55 per cent with sodium carbonate to get normal fermentation. In the case of peel juice, the fermentation was done with pre-treatments like (*i*) filteration to remove suspended matter and pasteurization at 80°C, (*ii*) pasteurization without any filteration, (*iii*) without pasteurization and filtration. Wine prepared with treatment (*ii*) developed a bitter taste and off flavour. Wine from the other two lots had astringent taste which was overcome by precipitation of tannins with gelatin initially. Wine from pulp did not need any such treatments. Wines prepared from peel as well as pulp, had pleasant taste, mild mango flavour, and attractive yellowish colour after maturation for two months at RT. Peel and pulp waste as such, could not be fermented without pectic enzyme treatment and press-out. Vinegar prepared by "Let-alone" method had pleasant taste and aroma when matured over a period of two months. In the case of peel syrup, partial precipitation of tannins, as in the case of wines, was found necessary to get rid of undue astringency. Syrups recovered from dried materials too gave satisfactory wine (9 per cent alcohol) and vinegar (total acidity, 4.5 per cent and volatil acidity, 3.75 per cent).

Acknowledgement

The authors are thankful to Dr. B. L. Amla, Director of the Institute, and to Dr. D. P. Sen, Scientist for their keen interest in this work.

References

1. *Fruits and Vegetable Preservation Industry in India-Statistics of Production and Export*, Directorate of Marketing and Inspection, Nagpur, 1970.
2. *Food Preservation and Canning Industry in U.S.A. and Denmark*, National Productivity Council Report No. 33. March, 1964.
3. Parekh, C. M., Pruthi, J. S. and Lal Girdhari, *Indian Fd Pckr*, 1959, **13** (6), 7.
4. Johar, D. S., Krishnamurthy, G. V. and Bhatia, B. S., *Food Sci*, 1960, **9**, 82.
5. Jain, N. L., Das, D. P. and Lal Girdhari, *Indian Fd Pckr*, 1952, **6** (8/9), 23.
6. Satyavati, V. K., Bhat, A. V., Varkey George, A. and Mookerji, K. K., *Indian Fd Pckr*, 1972, **26** (3), 50.
7. Pruthi, J. S., Krishnamurthy G. V. and Lal Girdhari, *Indian Fd Pckr*, 1959, **13** (4), 7.
8. Pruthi, J. S. and Susheela, R., *Punjab hort. J.*, 1963, **3**, 272.
9. *Official Methods of Analysis*, A.O.A.C., Washington D.C. 1975.
10. Carre, M. H. and Haynes, D., *Biochem. J.*, 1922, **16**, 60.

Studies on the Use of Dry Earth as a Contact Medium for Absorbing Moisture from Paddy

T. SRINIVAS, S. N. RAGHAVENDRA RAO, M. K. BHASHYAM AND H. S. R. DESIKACHAR
Central Food Technological Research Institute, Mysore, India

Manuscript Received: 4 *May* 1976

The possibility of drying paddy by keeping in contact with pre-dried moisture absorbing media was investigated. Fullers earth, Bentonite, saw dust, sand, salt, black earth and red earth were tried as contact media. The last two were found to be more effective than others. Data on rate of drying, effect of varying the ratio of earth to paddy, suitability of using the earth repeatedly, effect of temperature of the contact medium, as also crack formation and milling breakage of dried paddy were collected. Drying paddy continuously from 20 to 12% moisture in three steps in contact with dry black earth has been successfully carried out. Black earth has been found to be superior to red earth in view of its better sorptive property.

It is now established that paddy has to be harvested at moisture levels of about 22-24 per cent and dried carefully immediately after threshing for best milling results[1,2]. Both sun drying as well as drying by mechanical means using hot air are in vogue and the conditions have been standardised[3,4]. Hot sand and momentary passage through hot atmosphere have also been used for drying[5]. The use of sodium chloride not only for extracting moisture but also for preserving the moist paddy has also been reported[6].

Where mechanization of drying is not possible as in the village or where sun drying is not possible because of rain or inclement weather a simple practicable method of drying the paddy is desirable. In view of the high susceptibility of the paddy grains to development of checks or cracks due to sudden changes in temperature or moisture content[7,8], paddy cannot be directly given heat treatment like roasting or toasting for reducing the moisture content. Reduction of moisture in paddy by contact with dry earth was considered as a possibility and result of investigation to study the potential of dry earth and a few other materials as contact media for absorbing moisture from paddy are presented herewith. The suitability of different types of earth, effect of contact time and temperature, proportion of earth to paddy, efficiency of earth in repeated use, etc, have been investigated.

Materials and Methods

Comparative screening of different contact media: The contact media tested for their suitability to remove moisture from paddy were black earth, red earth, Fullers' earth, Bentonite, common salt, sand, saw dust and paddy husk ash. In these studies, the contact materials were dried by roasting in a pan to a temperature of about 150°C, cooled to room temperature in a closed vessel and were mixed with freshly harvested paddy in the same proportion (1 part of medium to 2 parts of paddy were used arbitrarily in these studies) and put in closed bottles. At the end of one hour contact time, the drying medium was sieved out and moisture of paddy and the drying medium determined using oven method by drying at 105°C for 24 hr with a correction factor of 1 per cent[9]. Because of their fine particle size Bentonite and Fullers' earth could not be separated fully from the paddy by sieving. Saw dust presented problems of fire hazards during roasting. The black and red earths did not present the above difficulties and were therefore used for further detailed investigations.

Comparison of hot and cooled dry earths: Hot dry earth may effect more moisture removal but would be expected to affect adversely the milling quality by inducing crack formation in paddy. A comparison was therefore made to study the extent of this effect.

The black and red earth samples, dried by roasting to 150°C, were cooled to 105°C and also to room temperature and were mixed with paddy in the ratio of 1:2 and equilibrated for 24 hr and the paddy moisture was determined after sieving. The paddy grains were examined for crack formation using a crack detector developed in this Institute[10]. The partially dried paddy samples were further dried in the shade to 14 per cent moisture for milling quality analysis.

Milling quality was determined using a McGill sheller and broken grains during shelling operation were determined[11].

Rate of moisture equilibration between paddy and earth: Paddy samples in two varieties and having different initial moisture (27, 21 and 18 per cent) were mixed with cool dry black earth in the ratio of 2:1 and equilibrated in closed bottles and also in open dishes for

1, 2, 4, 6, 8 and 24 hr. After each interval the paddy was sieved from the earth and its moisture content was determined.

Moisture removal using different proportions of paddy to earth: In all the above comparative studies the proportion of earth to paddy had been fixed arbitrarily at 1:2. In order to arrive at the optimal working ratio, equilibration of the earth and paddy was carried out for one hour using ratios varying from 0.1 to 2 and moisture removal from paddy determined as before.

Redrying of used earth for subsequent drying of paddy: To study the above aspect, earth sample used for first contacting with paddy was sieved out, dried by roasting, cooled and reused for a second drying study. This was repeated two more times and moisture removal efficiency during each cycle was determined.

Drying of paddy in bulk by multipass mixing of earth: Black earth roasted in an electrical roaster or in an iron pan over a fire or in an oven was cooled to about 105°C and mixed with bulk quantity of paddy (80 kg) in 1:2 proportion. After a contact period of 2 hr the paddy was sieved out and again mixed with dry earth as before. This process was repeated once more and the moisture content, per cent cracked grains and shelling brokens were determined in samples collected after each pass.

Sorption capacity of black and red earths: The two earths (−44+60 B.S. mesh) were dried and cooled in a desiccator and fractions were spread in petri-dishes in unilayer thickness and exposed in a chamber maintained at relative humidity of 90 per cent and temperature of 38°C. Moisture absorption after exposure for different periods of time was determined.

Results and Discussion

Suitability of different drying media: Results on the relative efficiency of different types of drying media tried are presented in Table 1 from which it will be seen that black earth, red earth, Fullers' earth, Bentonite and saw dust effected high moisture withdrawal from the paddy and were superior to salt. Sand and paddy husk ash under comparable conditions had a very low efficiency of moisture removal. The Fullers' earth and Bentonite which were finely divided (−150 B.S. mesh) had the disadvantage of adhering to the paddy surface during sieving while the saw dust presented problems of fire hazard during roasting. Further detailed studies were therefore restricted to red earth and black earth only.

Hot vs *cold earth:* The hot earth at 105°C, removed about 25 per cent more moisture from the paddy than the cold earth under comparable conditions without materially increasing milling breakage or cracking, (Table 2) although in the case of the variety Madhu some cracking (3.8 and 7.3 per cent) was induced by contact with the hot earths. The extent of moisture removal was greater with higher initial moisture content of the paddy. The above studies would indicate that for drying paddy varieties with fair milling quality (IR 20) hot earth can be used without disadvantage while for varieties that have poor milling quality (Madhu) use of cold earth may be preferred. This aspect has to be checked with more paddy varieties.

TABLE 1. RELATIVE EFFICIENCY OF DIFFERENT CONDUCTION MEDIA FOR REMOVING MOISTURE FROM PADDY IN 1 HOUR

Contact medium	Ratio of medium: paddy	Moisture of dried paddy %	Moisture absorbed by contact medium %
Black earth (M)	1:2	18.1	2.7
Red earth (M)	1:2	19.2	1.6
Fullers' earth (F)	1:2	18.2	2.6
Bentonite (F)	1:2	18.4	2.4
Sand (C)	1:2	20.6	0.2
Saw dust (C)	1:2	18.7	2.3
Paddy husk ash (C)	1:2	19.8	0.5
Salt	1:20	19.7	1.1
	1:10	19.3	1.5
	1:5	19.3	1.5
	1:2	19.1	1.7

C = Coarse (−25 fraction); F = Fine (−150 fraction); M = Medium (−44+60 fraction). Initial moisture of paddy is 20.8%.

Rate of drying of paddy in contact with medium: Data presented in Fig 1 show that the drying of paddy effeted by contact with the drying medium for definite

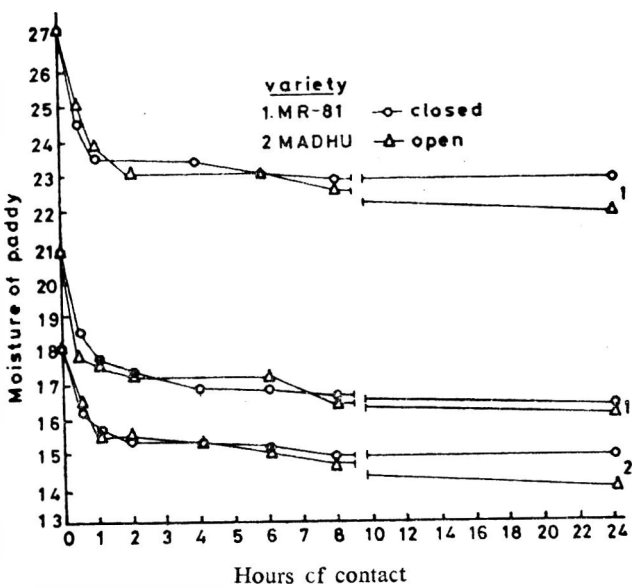


Fig. 1. Rate of moisture removal from paddy mixed with dry black earth under open and closed conditions.

TABLE 2. MOISTURE REMOVAL FROM PADDY AFTER 24 HOURS CONTACT WTIH EARTH

Variety	Contact medium	Temperature of the contact medium (°C)	Net moisture removed from paddy (%)	Cracked grains (%)	Brokens in shelling (%)
IR-20 (initial moisture, 24.2%)	Black earth	105	6.3	0	14.3 (11.8)
	Red earth	105	3.5	0	11.4
	Black earth	30	5.4	0	13.3
	Red earth	30	3.4	0	11.8
Madhu (initial moisture, 19.1%)	Black earth	105	4.2	7.3	26.3 (24.0)
	Red earth	105	2.1	3.8	25.7
	Black earth	30	3.3	0	25.5
	Red earth	30	1.6	0	25.5

Figures in parenthesis represent breakage in shade dried control paddy.

periods is a falling rate process. Drying rate was fast in the first 1-2 hr afterwards it was very slow. These data indicate that in development of a practical drying method by this technique, contact between paddy and the drying medium in any drying pass need not exceed two hours (Fig 1). The data also demonstrate that there is no appreciable difference between the trials in closed containers and open dishes with regard to drying efficiency. The slight efficiency observed is in favour of open drying. This is all the more interesting in view of the fact that these trials were carried out intentionally on a cloudy day when the ambient R.H. was about 85 per cent.

Effect of proportion of contact medium: With regard to the optimal proportion of earth to be mixed with the paddy the curve presented in Fig 2 demonstrates that moisture withdrawal was obviously higher, the greater the proportion of the earth although the curve reaches almost a plateau at ratios higher than 1. Earth to paddy ratio varying from 0.5 to 0.75 appears to be practical although the economical working ratio

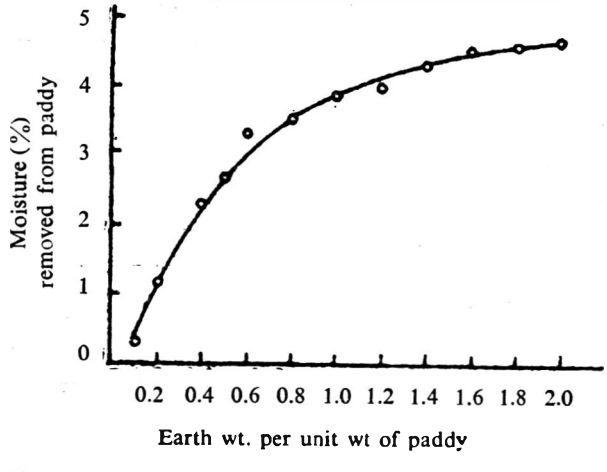


Fig. 2. Moisture removal from paddy mixed for 2 hr with different proportions of earth.

should be worked out further on considerations of heat economy.

Repeated use of earth: The practicability of using the contact medium repeatedly for subsequent drying by roasting it after each drying pass is shown in Table 3. Even after repeated use in four drying cycles the drying efficiency of the earths was not adversely affected. These data further stress the superiority of black earth over red earth. The moisture absorption capacity of the latter is only about 75 per cent of that of the black earth when the material is –60 mesh and only 60 per cent when the earth is coarser (–44+60 B.S. mesh).

Continuous drying of paddy by repeated use of earth: Data presented in Table 4 show that bulk drying of paddy with dry earth was as efficient as in the laboratory drying. Mixing and sieving of earth did not present any problem. It is also interesting that although the moisture removal was at the rate of about 1.5 per cent per hr the milling quality of paddy was not materially affected even by drying to a level of 11 per cent moisture. It was found earlier that during sun drying moisture removal from paddy at this rate caused higher shelling breakage[3]. These studies have to be confirmed on more varieties of paddy.

TABLE 3. MOISTURE ABSORPTION EFFICIENCY OF EARTHS ON REPEATED USE

	Moisture (%) absorbed after mixing for 1 hr.			
	Black earth		Red earth	
	Fine	Medium	Fine	Medium
I Pass	4.1	4.0	3.4	2.5
II Pass	3.8	4.0	3.0	2.4
III Pass	4.1	4.1	3.2	2.6
IV Pass	4.1	4.3	3.2	2.4

Fine = –60 fractior ; Medium = –44+60 fraction.

TABLE 4. CONTINUOUS DRYING OF PADDY IN BULK (80 KG) IN THREE PASSES USING 2 HOUR CONTACT PERIOD DURING EACH TREATMENT

(Initial moisture content of paddy: 21.1%)

Treatment	Net moisture removed from paddy (%)	Cracked grains (%)	Brokens during shelling (%)
I Pass	3.4	2 (2)	4.0 (2.7)
II Pass	2.7	3	3.9
III Pass	3.3	4	3.8
III Pass after 14 hr.	0.2	10	6.9

Figures in paranthesis represent comparative values for paddy dried in shade.

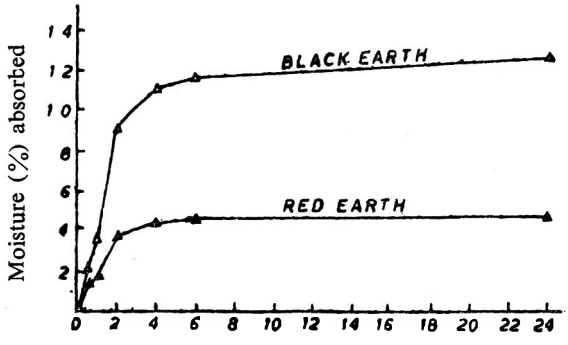


Fig. 3. Rate of moisture absorption by dry black and dry red earths exposed to 90% R. H.

Sorption capacity of black and red earth: The sorption curves for black and red earth are presented in Fig. 3. The black earth could absorb nearly double the amount of moisture as compared with red earth from a humid atmosphere indicating its superiority for use as a drying medium. However, in regions where black earth may not be readily available, the red soil could still be used for drying. Probably higher ratio of earth to paddy may be needed.

The present laboratory studies have indicated that black or red earth dried by roasting to 150°C can effect 3-4 per cent moisture reduction when kept in contact with freshly harvested paddy for about 2 hr. The suggested ratio of earth to paddy is about 0.5 to 0.75 and the earth could be repeatedly used for further drying after roasting. Scale up studies to investigate the economic utility of the process are contemplated.

Acknowledgement

The authors thank Mr S. Sreedhara Murthy for assistance in drying studies and Mr. K. Nanjundaiah for preparing figures. The kind assistance of Dr. M. Madhadevappa of VC Farm, Mandya in supplying high moisture paddy is gratefully acknowledged.

References

1. Morse, M. D., Lindt, J. H., Oelke, E. A., Brandon, M. D. and Curley, R. E., *Rice J.*, 1967, **70**, 16.
2. Ranganath, K. A., Bhashyam, M. K., Bhaskar Rao, Y. and Desikachar, H.S.R., *J. Fd Sci. Technol.*, 1970, **7**, 144.
3. Bhashyam, M. K., Srinivas, T. and Desikachar, H.S.R., *J. Fd Sci. Technol.*, 1975, **12**, 124.
4. Angladette, A., *Rice Drying Principles and Techniques. Informal Work. Bull.*, **23**, F.A.O. Agric. Engng Branch, United Nations, 1963.
5. Khan, A.U. and Chancellor, W. J., *Accelerated Drying of Rice Using Heat Conduction Media*, Paper No. 73-321, Presented at the 1973 Annual Meeting. American Society of Agricultural Engineers, Kentucky, U.S.A.
6. Subrahmanyan, V., *Proceedings of the Seminar on Post Harvest Technology of Cereals and Pulses.* Published by Indian National Science Academy, Indian Council of Agricultural Research, Council of Scientific and Industrial Recearch, and Food Corporation of India, New Delhi, 1972, 64.
7. Henderson, S. M., *Rice J.*, 1954, **57**, 16.
8. Kunze, O. R. and Hall, C. W., *Trans. Am. Soc. agric. Engr*, 1965, **8**, 396.
9. Indudhara Swamy, Y. M., Ali, S. Z. and Bhattacharya, K. R., *J. Fd Sci. Technol.*, 1971, **8**, 20.
10. Srinivas, T. and Desikachar, H.S.R., *J. Fd Sci. Technol.*, 1973, **10**, 197.
11. Raghavendra Rao, S. N., Narayana, M. N. and Desikachar, H.S.R., *J. Fd Sci. Technol.*, 1967, 4, 150.

Distribution Pattern of Micellar and Soluble Casein of Goat Milk as Revealed by Differential Ultracentrifugation

AJIT SINGH AND N. C. GANGULI
National Dairy Research Institute, Karnal, India.

Manuscript Received: 2 *March* 1976

Goat milk was studied to evaluate the distribution of its micellar casein and solble casein by differential ultracentrifugation. It was observed that major portion (84.62%) of micellar casein settled at 11,000×g (MC-I), whereas only 10.38 and 5.28% settled between 11,000-46,000× g and 46,000-105,000× g (MC-II and MC-III), respectively, unlike cow milk. The values for cow milk were 36. 69, 47.69 and 15.61%, respectively. These data show that goat milk micelle particles are bigger in size than that of cow milk.

Sialic acid, hexose and hexosamine contents were more in small micelle particles. The particle size appeared to be inversely proportional with sialic acid, hexose and hexosamine concentration with of the micelles. On the other hand calcium and phosphorus contents increased in micelles with increasing micellar size. In case of the nitrogen content, the reverse was the case. The release of sialic acid was found to be more in micellar casein than the acid casein. Micellar casein of larger size gave highest sialic acid release on rennet action. Large size micelles exhibited higher opaciry and as well as more turbidity formation on rennet action than the medium and small size micellar caseins

Recently, Sabarwal and Ganguli[1] reported the sedimentation behaviour of buffalo and cow milk micellar casein. They indicated that buffalo milk micellar casein particles are larger in size than the corresponding cow milk whereas the soluble casein was considerably less in buffalo milk. However, there appears to be no such report available on the distribution pattern of micellar and soluble casein in goat milk. This evoked our interest to study the distribution pattern and physico-chemical properties of micellar casein of goat milk. The present paper reports these results. Cow milk samples were also analysed for comparison.

Materials and Methods

Milk samples were collected from Beetle goats and Tharparkar cows, maintained at the Institiute. Pooled milk samples or milk from the indvidual animals were collected as per the need of the various experiments. Fat was removed by skimming the milk with the help of Alfa-Laval cream separator.

Preparation and estimation of casein fractions: The casein fractions of varying sizes were prepared by centrifuging milk at different speeds such as 11,000, 46,000 and 105,000×g for 30 min using a Beckman Model L preparative ultracentrifuge according to Sabarwal and Ganguli[1].

The casein fractions, whey fractions, soluble casein, non-casein protein and non-protein components were evaluated as follows:

Milk was ultracentrifuged at 11,000×g for 30 min and the ultracentrifugal whey (UCW I) was pipetted out taking care that it did not mix with the casein micelle sedimented at the bottom. The micellar casein obtained at this speed was referred as MC-1.

The supernatant obtained was again centrifuged at 46,000×g i.e. 20,000 rpm for 30 min. The UCW II was carefully pipetted out as before and the sedimented micelle thus obtained was referred as MC-II.

Likewise UCW II was spun at 105,000×g i.e. 30,000 rpm for 30 min so as to settle the remaining casein micelle particles. This fraction was referred as MC-III and the supernatant as UCW III.

The proportion of the casein micelles settled at these speeds was ascertained by using following calculations.

(*a*) MC-I=Total protein in milk-protein in UCW I
(*b*) MC-II=Protein in UCW I-protein in UCW II
(*c*) MC-III=Protein in UCW II-protein in UCW III

Estimation of soluble casein: The supernatant obtained from milk after centrifuging at 105,000×g for 30 min (i.e. UCW III) was adjusted to pH 4.6 with 10 per cent acetic acid. The mixture was kept at 37°C for 30 min to ensure complete precipitation of soluble casein. The soluble casein (SC) content was then estimated by difference from the protein contents in UCW III before and after the removal of the casein precipitate.

Estimation of non-casein protein and non-protein contents: The supernatant obtained after removing of soluble casein (as indicated above) was further treated with equal volume of 16 per cent trichloroaceticacid (TCA) for precipitating non-casein proteins. The non-protein constituents were estimated in the

TCA filtrate and the non-casein protein content was evaluated by difference.

Other analytical methods: Protein content was evaluated in all fractions by the method of Lowry *et al*[2] using Folin-Ciocalteu reagent. All samples were diluted 50 times with distilled water before estimation. Goat acid casein was used as standard with suitable dilutions.

Sialic acid of casein fractions was estimated by the thiobarbituric acid assay method of Warren[3] as modified by Gupta and Ganguli[4]. Hexose of micellar casein fractions was determined following the method of Winzler[5] using orcinol sulphuric acid reagent. Hexosamine was estimated according to the procedure of Rimington[6] with certain modifications[7].

The calcium from micellar casein fractions was estimated following the method of Davies and White[8] using EDTA. The phosphorus content of different particle size micelles was evaluated by the method of Fiske and Subba Row[9]. The nitrogen content of micellar casein fractions was determined by micro-Kjeldahl method of AOAC[10].

The rennet action was evaluated by:

(*i*) *Release of sialic acid:* The release of the bound sialic acid from micellar and acid caseins by rennet was evaluated following the method of Gupta and Ganguli[11].

(*ii*) *Opacity measurements:* Micellar casein in maleate buffer, pH 6.5, was used for opacity measurements at 600 nm according to Sabarwal and Ganguli[12].

Rennet action on casein micelles was assayed by measuring the increase in turbidity using the procedure of Sabarwal and Ganguli[13].

Results and Discussion

Distribution pattern of micellar casein of goat milk: Perusal of Table 1 would reveal that most of the micellar casein of goat milk settled at the lowest speed at 11,000 × **g**. The distribution of MC-I, MC-II and MC-III in the total micellar casein was 2.35, 0.28 and 0.14 g/100 ml milk, respectively. The larger portion of the micellar casein (84.6 per cent) settled at lowest speed. Further the proportion of micellar casein settled diminished with the increase of ultracentrifugation force used.

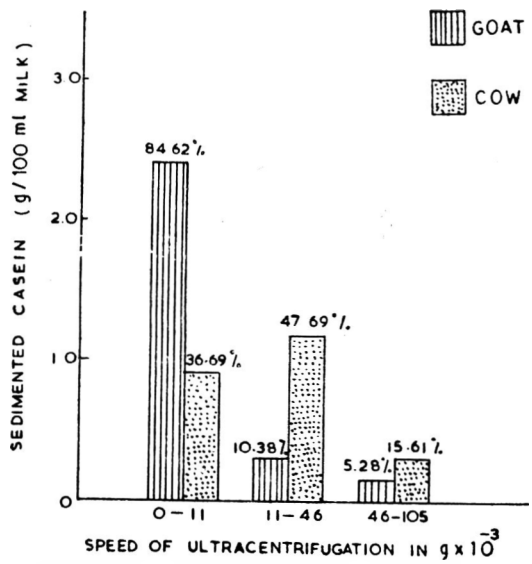


Fig. 1. Distribution pattern of micellar casein sedimented by differential ultracentrifugation.

Micellar casein collected at a speed of 11,000–46,000 × **g** (MC-II) and 46,000–105,000 × **g** (MC-III) constituted 10.3 and 5.2 per cent of the total micellar casein of goat milk.

Unlike goat milk, the quantity of medium size (MC II) particles was highest in cow milk followed by large and small size micelle. Micellar casein settling at 46,000 –105,000 × **g** (MC-III) was remarkably high (15.6 per cent) as compared to goat milk (5.3 per cent). The summarized variation profile is depicted in Fig. 1.

Soluble casein in relation to micellar casein: The results obtained on the proportion of soluble casein in milk are shown in Table 2 and compared with micellar casein (total micelle).

The SC of goat milk has been found to be 0.14g/100 ml milk (5.0 per cent of total casein) as compared to 2.7 g/100 ml milk (94.9 per cent) of micellar casein giving a MC to SC ratio of 18.7. Whereas the corresponding values for cow milk are 0.13g/100 ml (5.4 per cent), 2.38 g/100 ml (94.6 per cent), and 17.51, respectively. It is apparent, therefore, that there is not much difference in the distribution pattern of soluble and micellar casein in these two milk samples.

TABLE 1. DISTRIBUTION OF MICELLAR CASEIN SETTLED AT DIFFERENT SPEEDS OF ULTRACENTRIFUGATION

Milk source	Micellar casein fractions (g/100 ml milk)*					
	MC-I		MC-II		MC-III	
	Range	Average	Range	Average	Range	Average
Goat	2.14–2.55	2.35±0.08 (84.62)	0.19–0.40	0.28±0.42 (10.38)	0.10–0.15	0.14–0.07 (5.28)
Cow	0.53–0.97	0.87±0.10 (36.69)	0.93–1.48	1.13±0.09 (47.69)	0.25–0.57	0.37±0.06 (15.61)

*Number of samples analysed in each case was five. Figures in parantheses indicate results in percentage.

TABLE 2. PROPORTION OF SOLUBLE AND MICELLAR CASEIN IN GOAT AND COW MILK

Milk source	Casein (g/100 ml milk)* Soluble casein (SC) Range	SC Average	Micellar casein (MC) Range	MC Average	MC/SC ratio
Goat	0.13–0.16	0.14±0.07 (5.01)	2.56–2.97	2.78±0.10 (94.98)	18.7
Cow	0.05–0.21	0.13±0.12 (5.40)	2.08–2.46	2.38±0.18 (94.59)	17.5

*Number of samples analysed in each case was five. Figures in parantheses indicate results in percentage.

Distribution of proteins in goat and cow milk: Results on the different protein fractions given in Table 3 indicate that the total protein in goat was 3.65 g/100 ml which consists of 80.3 per cent casein (76.2 per cent micellar and 4.0 per cent soluble casein). The non-casein protein content and non-protein components were assessed to be 18.4 and 1.4 per cent, respectively. The corresponding data for cow milk were evaluated to be 3.34 g/100 ml out of which 75.3 per cent was casein (71.3 per cent micellar and 4.0 per cent soluble casein), 24.7 per cent non-casein protein and 2.3 per cent non-protein components. Goat milk, therefore, contains higher proportion of total casein, micellar casein as compared to cow milk. Whereas, whey proteins and non-protein components are low in goat milk. Our results on the distribution of proteins into casein, whey proteins and non-protein components (Table 3) in goat and cow milk agree fairly well with the reported values on these species[1,7].

Chemical make-up of micellar casein fractions: The micellar casein fractions collected by differential ultracentrifugation were analysed for its sialic acid, hexose, hexosamine, calcium, phosphorus and nitrogen contents. The opacity of the micelles and susceptibility towards rennet were also ascertained. The results of such analyses are being delineated below.

(a) Dependence of carbohydrate contents on the particle size of micellar casein: The sialic acid, hexose and hexosamine contents were estimated from the micellar casein fractions obtained by differential ultracentifugation and results are borne out in Table 4.

It is clear that the smaller size particles are richer in its sialic acid content. The micellar casein fraction collected at the highest speed of ultracentrifugation (small size particles) contains higher amount of sialic acid and reverse is the case with large size particles collected at lowest speed. Such findings can be explained in the light of the observations recorded by Annibaldi[14] and Yoshida *et al*[15]. The sialic acid moiety being attached to the *k*-casein[16], it can be visualized that small micellar casein particles are, therefore, richer in *k*-casein. The sialic acid distribution in different micellar casein fractions i.e. large, medium and small was observed to be 13.0, 17.7 and 69.2 per cent, respectively.

The hexose contents of different micellar casein fractions (Table 4) show that small micelle

TABLE 3. DISTRIBUTION OF TOTAL PROTEIN AND NON-PROTEIN COMPONENTS OF MILK*

Milk source	Total protein Range	Total protein Average	Micellar casein* Range	Micellar casein* Average	Soluble casein* Range	Soluble casein* Average	Total casein Range	Total casein Average	Non-casein protein (whey protein) Range	Non-casein protein (whey protein) Average	NPC (g/100 ml) Range	NPC (g/100 ml) Average
					(g/100 ml of milk)							
Goat	3.36–3.69	3.65±0.16	2.56–2.98	2.78±0.11 (76.23)	0.13–0.16	0.15±0.07 (4.03)	2.72–3.13	2.93±0.11 80.25)	0.40–0.89	0.67±0.11 (18.35)	0.01–0.07	0.05±0.001 (1.39)
Cow	2.98–3.55	3.34±0.09	0.09–2.46	2.38±0.09 (71.2/)	0.06–0.21	0.14±0.12 (4.06)	2.42–2.73	2.52±0.06 (75.34)	0.53–0.98	0.82±0.13 (24.65)	0.06–0.14	0.08±0.09 (2.33)

*Number of samples analysed in each case was five. Figures in the parantheses indicate per cent.

TABLE 4. SIALIC ACID, HEXOSE AND HEXOSAMINE CONTENT OF MICELLAR CASEIN FRACTIONS OBTAINED BY DIFFERENTIAL ULTRACENTRIFUGATION

Ultracentrifugation speed ×g	Sialic acid (mg/g) Range	Sialic acid % of total	Hexose (mg/g) Range	Hexose % of total	Hexosamine* (mg/g) Range	Hexosamine % of total
0–11,000	0.41–0.57 (0.46±0.01)	13.08	24.97–29.73 (27.80±0.19)	22.18	5.00–6.00 (5.69±0.27)	27.26
11,000–46,000	0.59–0.67 (0.63±0.01)	17.65	37.68–44.27 (39.55±0.45)	31.55	6.75–7.00 (6.87±0.01)	32.91
46,000–105,000	2.36–2.70 (2.48±0.01)	69.26	47.44–66.96 (57.99±8.92)	46.26	7.75–9.25 (8.31±0.35)	39.81

*Number of samples analysed in each case was five.

TABLE 5. CALCIUM, PHOSPHORUS AND NITROGEN CONTENT OF MICELLAR CASEIN FRACTIONS*

Ultracentrifugation speed ×g	Calcium %	Phosphorus %	Nitrogen %	Protein (N×6.38) %
0.0–11,000	3.07–3.14 (3.10±0.01)	1.18–1.63 (1.45±0.20)	11.63–12.85 (12.12±0.57)	74.11–81.98 (77.37±1.80)
11,000–46,000	2.75–2.93 (2.86±0.01)	1.02–1.10 (1.06±0.03)	12.21–12.87 (12.16±0.28)	77.89–82.11 (80.49±0.97)
46,000–105,000	2.27–2.86 (2.56±0.04)	0.71–1.03 (0.85±0.14)	12.38–12.92 (12.64±0.22)	78.98–82.42 (80.65±0.68)

*Number of samples analysed in each case was five.
Data in parentheses are average±S.E.

particles are rich in hexose content also. Particles collected at highest speed gave the highest value of 57.99 mg/g and the micelle obtained at lowest speed have the lowest content of 27.80 mg/g hexose. The hexose distribution in different micellar casein fractions was noted to be 22.2, 31.6, 46.3 per cent respectively. The micellar casein fractions collected at different speed of ultracentrifugation showed higher hexose values than the whole micellar casein[7] (Table 4).

A similar situation was noted with the hexosamine content of micellar casein fractions. The small micelle particles contain maximum amount (8.31 mg/g) and large particles had lowest content of hexosamine.

(*b*) *Dependence of calcium, phosphorus and nitrogen contents on the particle size of micellar casein:* The results on the calcium, phosphorus and nitrogen contents of the different particle size of micellar caseins have been shown in Table 5.

The calcium content showed an increase with increasing micellar size, i.e. large micellar had higher calcium content than the medium and small ones. These values in goat micellar casein fractions were 3.1, 2.9 and 2.5 per cent respectively. The rate of decrease from large to medium and large to small micelle was 7.6 and 17.3 per cent, respectively. Like calcium, micellar casein of largest size was having maximum phosphorus content (1.45±0.20 per cent), which gradually decreased with the decrease in the micellar size.

Hence, the phosphorus content is directly proportional to the size of casein micelle particles. The decrease of phosphorus content from large to medium and large to small particles size was in the order of 26.55 and 41.18 per cent, respectively. The presence of high calcium and phosphorus content with the bigger micellar casein particle size (Table 5) suggests that in addition to other factors, variation in the micelle size may be due to variations in calcium and phosphorus content.

The nitrogen level on the contrary increased with decreasing micelle-particle size. The casein micelle collected at 11,000×g showed lowest nitrogen level (12.12±0.28 per cent) as compared to micelle fractions collected at higher speeds of ultracentrifugation. The nitrogen content increased by 4.3 per cent from large to small micelle and the increase from large to medium sized particles being 0.331 per cent.

Rennin susceptibility of casein micelles

(*a*) *Release of sialic acid from micellar and acid caseins of goat milk by rennet:* Results in Table 6 show that the release of bound sialic acid was more in case of micellar casein than the corresponding acid casein prepared from the same milk, these values being 69.4 and 57.5 per cent, respectively. The higher release of sialic acid by rennet from micellar casein than the acid casein prepared from the goat milk gives an impression that casein in its native state seems to be more susceptible to rennet action (Table 6). Nain *et al*[17] also reported similar results on the sialic acid release by rennet on goat acid casein. Caseins prepared from goat milk showed lesser rate of sialic acid release than the corresponding caseins prepared from cow and buffalo milk[18].

These data (Table 6) further elicit that although the larger micellar casein particles are poor in sialic acid (Table 4) maximum release of the sugar moiety was

TABLE 6. SIALIC ACID RELEASE FROM ACID, MICELLAR, K-CASEIN AND MICELLAR CASEIN FRACTIONS BY RENNET

Type of casein	Sialic acid release (%)* Range	Average
Acid casein	51.60–64.2	57.5
Micellar casein	58.6–84.9	69.4
k-casein	63.8–79.5	72.3
Micellar casein I (11,000×g)	75.9–94.9	87.2
Micellar casein II (11,000–46,000×g) Medium	66.3–82.0	74.8
Micellar casein III (46,000–105,000×g) Small	46.6–60.1	54.2

*Number of samples analysed in each case was five.

TABLE 7. OPACITY OF MICELLAR CASEIN FRACTIONS OF GOAT MILK IN MALEATE BUFFER, PH 6.5

Type of micelles	Casein concn (%)	Opacity at 600 mμ* Range	Average
Whole micellar casein	1.00	0.12–0.28	0.18
0–11,000×g	1.00	0.22–0.33	0.26
11,000–46,000×g	1.00	0.11–0.17	0.13
46,000–105,000×g	1.00	0.06–0.09	0.07

*Number of samples analysed in each case was five.

observed by rennet in this fraction. Sabarwal and Ganguli[18] reported similar observations on micellar casein fractions prepared from cow and buffalo milk.

(*b*) *Opacity of micellar casein and its fractions*: The opacity of micellar casein was determined using maleate buffer, pH 6.5, as described in the experimental methods. Table 7 indicates that the large micelles gave higher opacity than the medium size and small size micelles, and, therefore, directly proportional to micelle size. Opacity of whole micellar casein was also higher than micellar casein fractions collected at higher speed of ultracentrifugation. Positive correlation between calcium content (Table 5) and opacity (Table 7) of the different micellar casein fractions stress upon the function of calcium in determining the opacity of micellar casein.

(*c*) *Turbidity profiles in micellar caseins on rennet action*: Susceptibility of goat milk casein micelles to rennet was also assessed by turbidity development procedure. It was observed (Fig. 2) that the rate of turbidity development decreased with the particle size and hence directly proportional to the particle size of the micellar casein.

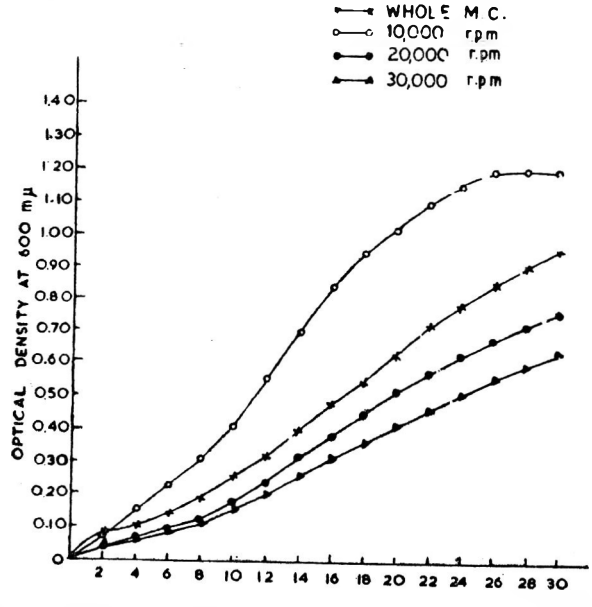


Fig. 2. The rate of turbidity development by rennet in whole micellar casein and casein micelle fractions of different particle sizes from goat milk at 1.0% substrate (casein) concentration using maleate buffer pH 6.5 at 37°C.

The higher rate of turbidity production might be due to more calcium present in the bigger size micelle particles compared to smaller micelles (Table 5). The higher rate of turbidity production (Fig. 2) with goat micellar casein supports the earlier finding[19] that this milk clots more rapidly than cow milk.

There appears to be a positive correlation between sialic acid release (Table 6) and turbidity development (Fig. 2). It is suggested that turbidimetric studies can be further utilized to understand the mechanism of rennet action on micellar casein. The present observations clearly demonstrate that action of rennet on goat casein micelles is very much dependent on the particle size of micellar casein.

References

1. Sabarwal, P. K. and Ganguli, N. C., *Indian J. Dairy Sci.*, 1971, **24**, 16.
2. Lowry, O. H., Rosebrough, N. J., Farr, A. L. and Randall, R. L., *J. biol. Chem.*, 1951, **193**, 265.
3. Warren, L., *J. biol. Chem.*, 1959, **234**, 1971.
4. Gupta, S. K. and Ganguli, N. C., *Milchwissenschaft*, 1965, **20**, 10.
5. Winzler, R. J., *Methods of Biochemical Analysis*, Interscience Publication, New York, Vol. 2, 1955, 279.
6. Rimington, C., *Biochem. J.*, 1940, **34**, 931.
7. Singh, A. and Ganguli, N. C., *Indian J. Dairy Sci.* (in Press).
8. Davies, D. T. and White, J.C.D., *J. Dairy Res.*, 1962, **29**, 285.
9. Fiske, C. H. and Subba Row, Y., *J. biol. Chem.*, 1925, **66**, 375.
10. *Official Methods of Analysis*, Association of Official Agricultural Chemists, Washington, 1960, p. 189.
11. Gupta, S. K. and Ganguli, N. C., *Indian J. Biochem.*, 1965, **2**, 253.
12. Sabarwal, P. K. and Ganguli, N. C., *Indian J. Dairy Sci.*, 1970, **23**, 24.
13. Sabarwal, P. K. and Ganguli, N. C., *Indian J. Dairy Sci.*, 1969, **22**, 128.
14. Annibaldi, S., *Latte*, 1960, **40**, 593.
15. Yoshida, S., Arima, S. and Hashimoto, Y., *J. agric. Chem. Soc. Japan*, 1965, **39**, 71.
16. Marier, J. R., Tassier, H. and Rose, D., *J. Dairy Sci.*, 1963, **46**, 373.
17. Nain, C. K. Mathur, M. P., Walli, T. K., Nath, I. and Ganguli, N. C., *Indian J. Anim. Sci.*, 1971, **41**, 910.
18. Sabarwal, P. K. and Ganguli, N. C., *Indian J. Biochem.*, 1970, **7**, 73.
19. Puri, B. R. and Parkash, S., *Indian J. Dairy Sci.*, 1962, **5**, 114.

Physico-chemical Characteristics and Canning Trials of Some Varieties of Tomatoes Grown in Central India

O. P. BEERH* AND V. R. RANE**
CFTRI Experiment Station, Nagpur, India.

Manuscript Received: 29 *January* 1976

Twenty varieties of tomatoes grown under Nagpur conditions were examined for their physico-chemical characteristics and suitability for canning as whole tomatoes. Tomatoes of all the varieties were flat to round in shape except *Sanmarzano*, *Red Top* and *Ruth* which were pear shaped, oblong and oval respectively. Except *Vokal* variety in which the colour was purple/crimson, other varieties were red to deep red. The colour, after peeling was more intense in *Tukon* and *Tuck Queen* and deteriorated in *Prosperity* and *Best of All* varieties. Under identical canning conditions, *Red Top* variety was found to be the best for canning. The canned product had uniform red colour and did not show any disintegration either with or without calcium firming. Disintegration was also less in the variety *Prosperity* but it did not have the desirable attractive colour. Next in the order, with respect to canning, were *Ruth*, *Early Chathem*, and *Sanmarzano* varieties. They had good colour and the extent of disintegration was within permissible limits of 10%. Chemical constituents did not show any marked effect on canning behaviour of varieties. Elongated and pear shaped tomato varieties were found better suited for canning.

In India the production of tomato products has steadily increased from 350 tonnes in 1956 to 2158 tonnes in 1970[1]. Peeled whole tomatoes canned in tomato juice is an important item manufactured commercialiy mainly for supply to the Army. The disintegration of tomatoes in the cans is a serious problem which adversely affects the quality of the finished product. On account of this, some times large quantities of canned tomatoes are rejected by the Army which puts the industry to huge losses. Besides other factors, the incidence of disintegration and overall quality of the canned whole tomatoes depends on the variety used for canning.

For purposes of canning, tomatoes should have a uniform red colour, moderate size, smooth surface, and large proportion of solid meat of good flavour; soft and watery varieties and those having large seed cavities soften badly on canning. In America, the varieties *Stone*, *Pearson*, *Moran*, *Sanmarzano*, *Paragon*, etc., are generally preferred[2]. A number of workers have investigated different varieties with regard to their suitablity for processing[3-13]. Beerh and Bhatnagar[3] studied the canning behaviour of seven varieties of tomatoes and found *Red Top* as the best canning variety. In evaluating seven varieties for canning, Roy *et al*[14] reported *Chiku Grando* as best canning variety followed by *Roma* and *Red Pear*. The present paper describes the physio-chemical characteristics and canning behaviour of 20 varieties of tomatoes grown under Nagpur conditions.

Materials and Methods

Twenty varieties of tomatoes (Table 1) were selected for canning trials. Fully mature and ripe red tomatoes were obtained from the experimental plots grown in Nagpur under the ICAR scheme.

Physical characteristics were determined on twenty fruits selected at random from main lot. The shape and colour were noted by visual observations. Number of loculi were found out by cutting the fruits into transverse sections. Core and peel percentages were determined from the wastage during canning. For estimation of chemical composition, 10 ripe fruits were mascerated in a blender for 1 min and strained through 32 mesh sieve. Brix was determined by a hand refractometer and corrected to 20°C by using standard tables. Acidity, water-insoluble solids and calcium were determined by AOAC methods[15]; ascorbic acid by direct titration with 2-6 dichlorophenol indophenol; sugars by Lane and Eynon method, and pectin by Caree and Haynes method.

For the purpose of canning, fully developed ripe red tomatoes having firm texture were selected, washed thoroughly, cored, scalded for thirty seconds at 95°C, and peeled. Peeled whole tomatoes (530 g) were filled into 401×411 plain cans and covered with hot tomato juice containing 3 per cent sugar and 1.5 per cent salt. In the case of treated lots, 0.1 per cent calcium chloride

*C.F.T.R.I., Mysore, India.
**Government Community Canning Centre, Poona.

TABLE 1. PHYSICAL CHARACTERISTICS OF TOMATOES OF DIFFERENT VARIETIES

Variety	Length (cm)			Diameter (cm)			Fruit wt (g.)			Peel wt. after scalding %	Core %	Colour on full maturity
	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.			
Pusa Ruby	5.4	3.8	4.6	6.9	4.8	5.8	152	38	80.2	4.0	0.95	Deep red, uniform.
Vokal	5.3	3.7	4.7	7.8	4.6	5.8	122	40	85.3	9.3	0.55	Crimson/purple, uniform.
Tip Top	5.7	3.4	4.7	6.9	3.5	5.1	124	24	66.8	3.3	0.44	Deep red, almost uniform.
Prosperity	5.6	4.1	4.6	6.2	5.5	5.9	95	40	65.8	4.9	0.43	Red, not uniform.
Money Maker	5.7	3.8	4.6	6.6	3.5	4.9	123	28	64.4	3.2	0.40	Red, yellow around core.
Market King	5.8	3.6	4.7	6.3	4.0	5.4	107	37	72.1	4.7	0.49	Red, yellow around core.
Ruth	5.2	3.9	4.4	5.3	3.8	4.3	85	30	52.7	5.0	0.15	Red, uniform.
Tukon	6.1	3.0	4.7	8.5	4.9	6.8	115	22	67.0	3.4	0.75	Deep red, greenish around core.
Early Chathem	6.0	4.1	5.0	6.0	4.0	4.9	100	28	66.0	3.8	0.63	Deep red, uniform.
Best of All	6.0	3.3	4.6	7.0	4.0	5.2	128	30	72.8	3.4	0.43	Red, uniform.
Sanmarzano	7.6	4.5	6.5	4.4	2.5	3.5	80	17	45.4	7.3	0.15	Deep red, uniform.
Red Top	8.5	4.9	7.6	6.1	3.0	5.0	102	22	69.8	4.6	0.25	Deep red, uniform.
Ailsa Crag	5.1	3.8	4.2	5.1	4.0	4.6	79	38	52.3	6.4	0.72	Red, not uniform.
E.C. 14166	6.5	3.7	4.7	8.4	4.6	6.4	190	67	112.6	4.4	0.47	Red, uniform.
Tuck Queen	6.5	3.4	4.9	7.6	4.1	5.8	177	40	105.4	4.4	0.75	Red, uniform.
Poona 341	4.3	3.1	3.6	4.7	3.0	3.8	48	22	29.6	3.0	0.43	Deep red, perfectly uniform.
Meerti	4.9	3.2	4.3	6.8	4.0	6.0	114	25	67.9	3.1	0.51	Deep red, greenish around core.
Turi Alba	5.0	3.9	4.4	7.0	4.7	5.5	117	52	74.4	3.7	0.81	Deep red, perfectly uniform.
Type-9	4.7	3.0	3.9	7.3	3.5	5.1	105	25	65.0	4.7	0.71	Deep red, perfectly uniform.
K-0119	5.4	2.9	4.1	6.0	3.0	4.2	115	42	53.0	5.1	0.66	Red, uniform.

TABLE 2. CHEMICAL CHARACTERISTICS OF TOMATOES OF DIFFERENT VARIETIES

Variety	Acidity %	°Brix at 20°C	Water insol. solids %	Sugars %		Ascorbic acid mg/100 g	Calcium mg/100 g	Pectin mg/100 g
				Reducing	Total			
Pusa Ruby	0.58	4.45	1.15	2.23	3.46	18.54	20.4	109.6
Vokal	0.44	5.02	0.65	2.96	4.58	25.28	24.3	190.0
Tip Top	0.40	3.50	0.86	2.25	2.46	23.34	14.8	132.1
Prosperity	0.46	3.42	0.80	2.10	2.84	21.02	24.1	78.5
Money Maker	0.35	4.50	0.91	—	—	13.87	27.3	188.1
Market King	0.40	3.92	0.96	1.94	2.02	14.89	19.3	122.0
Ruth	0.37	5.25	1.13	2.05	3.66	18.54	22.4	78.7
Tukon	0.37	4.20	1.15	2.22	3.36	18.98	19.3	121.5
Early Chathem	0.48	3.20	0.74	1.34	2.38	11.38	19.3	77.3
Best of All	0.35	4.50	1.77	1.77	3.83	12.19	23.7	112.9
Sanmarzano	0.33	5.20	0.79	2.63	3.94	20.04	23.3	80.0
Red Top	0.35	4.00	1.03	1.89	3.57	15.43	22.6	144.7
Ailsa Crag	0.44	3.87	0.25	1.71	1.94	15.33	—	98.0
E.C. 14166	0.37	4.47	0.89	2.67	3.72	16.71	—	155.0
Tuck Queen	0.53	4.27	0.49	3.00	3.02	25.00	15.5	120.0
Poona 341	0.53	4.45	0.56	2.55	2.67	21.60	24.0	68.7
Meerti	0.69	4.13	0.36	2.04	3.10	21.30	16.7	124.7
Turi Alba	0.48	3.37	0.57	1.80	2.89	14.91	20.8	84.7
Type-9	0.64	4.45	0.17	2.27	3.40	17.37	18.3	124.6
K-1019	0.41	4.47	0.54	1.82	3.11	19.46	15.2	49.9

TABLE 3. CUT-OUT ANALYSIS OF CANNED TOMATOES OF DIFFERENT VARIETIES

Variety	Treatment*	Vacuum (cm.)	Head space (mm.)	Drained wt. (%)	Total tomatoes no.	Broken tomatoes no.	Breakage (%)	Taste and aroma	Tomato colour	Tomato texture
Pusa Ruby	1	24.0	4.0	55.9	9.3	5.0	52.0	4	Deep red,	V. soft
	2	25.6	4.3	60.0	9.0	2.6	29.1	4	Deep red,	Soft
Vokal	1	21.5	5.5	57.6	9.0	6.0	64.3	5	Purple red	V. soft
	2	22.5	7.0	61.9	6.5	2.0	29.8	5	Deep purple red	V. soft
Tip Top	1	28.3	4.6	56.2	10.3	4.0	39.0	5	Deep red	Soft
	2	28.3	4.0	58.8	8.3	1.0	12.6	5	Deep red	Sl. firm
Prosperity	1	28.3	5.3	58.0	9.0	1.3	15.3	3	Yellowish red	Soft
	2	25.0	5.6	61.3	8.3	nil	0.0	3	Yellowish red	Firm
Money Maker	1	30.0	4.0	53.8	9.6	6.6	72.1	4	Red-deep red	V. soft
	2	25.0	3.6	59.4	8.3	1.6	20.6	4	Red-deep red	Soft
Market King	1	29.3	4.7	52.6	8.0	5.3	66.6	3	Yellowish red	V. soft
	2	25.0	5.3	59.5	9.6	3.0	28.9	3	Yellowish red	V. soft
Ruth	1	22.5	5.0	56.5	17.0	4.0	23.5	4	Deep red	Soft
	2	21.5	5.5	63.2	17.0	nil	0.0	4	Deep red	Firm
Tukon	1	23.2	3.0	56.3	6.3	1.3	20.6	4	Red-deep red	Sl. soft
	2	32.6	3.3	57.3	6.3	0.7	9.7	4	Red-deep red	Sl. soft
Early Chathem	1	25.0	2.3	57.0	10.3	2.3	22.2	5	Red-deep red	Sl. firm
	2	25.0	1.6	58.6	9.6	0.3	4.1	5	Red-deep red	Firm
Best of All	1	29.0	5.7	59.0	10.3	1.3	15.0	3	Yellowish red	Soft
	2	23.5	4.0	58.5	8.0	0.5	6.3	3	Yellowish red	Sl. firm
Sanmrzano	1	21.0	5.0	60.1	10.5	1.5	14.5	5	Deep red	Soft
	2	32.5	10.5	63.0	8.5	0.5	6.3	5	Deep red	Sl. firm
Red Top	1	12.5	5.0	66.3	9.0	nil	0.0	5	Red-deep red	Sl. firm
	2	15.0	6.3	64.3	9.0	nil	0.0	5	Red-deep red	Firm
Ailsa Crag	1	27.5	4.0	59.1	10.5	5.0	47.2	3	Deep red	Soft
	2	40.0	6.0	58.5	8.5	4.0	34.3	3	Deep red	Sl. soft
E.C. 14166	1	21.5	5.5	56.2	6.5	2.0	39.3	4	Deep red	V. soft
	2	20.0	4.5	61.4	6.0	0.5	8.4	4	Deep red	Soft.
Tuck Queen	1	22.5	5.0	52.4	7.0	1.5	20.9	4	Deep red	V. soft
	2	21.5	4.5	62.2	8.0	1.5	18.4	4	Deep red	Sl. firm
Poona 341	1	25.0	2.0	57.9	15.0	3.0	20.0	5	Deep red	V. soft
	2	25.0	3.0	60.3	16.0	2.0	12.5	5	Deep red	Sl. soft
Meerti	1	28.3	5.3	49.0	7.6	6.6	87.5	5	Deep red	V. soft mashed.
	2	26.6	5.7	53.5	7.3	5.7	75.8	5	Deep red	V. soft mashed.
Turi Alba	1	21.6	7.0	61.3	7.0	2.3	32.8	4	Red	V. soft
	2	21.6	6.3	62.6	7.1	1.3	19.6	4	Red	Sl. firm
Type-9	1	25.0	3.0	52.1	12.0	11.0	91.4	5	Deep red	Mashed
	2	21.6	1.6	55.2	9.6	6.3	67.9	5	Deep red	V. soft
K-1019	1	18.5	4.5	57.2	8.0	1.5	18.4	4	Red	V. soft
	2	17.5	5.0	59.5	7.5	0.5	7.2	4	Red-deep red	Sl. firm

*1. Canned without adding $CaCl_2$; 2. Canned with added $CaCl_2$. V. = Very; Sl = Slight.

was added to the covering tomato juice. The cans were exhausted to attain can centre temperature of 82°C, sealed, processed for 35 min at 100°C, cooled in water and stored at room temperature (25–30°C). Cut out examination was performed after a storage period of 3 months. Head space and vacuum were measured by usual procedure, and drained weight by draining the contents of the can for 2 min on a sieve of 20.3 × 20.3 cm having eight mesh per 2.5 cm. Taste and aroma were assessed on a five-point scale, 5-very good, 4-good, 3-satisfactory, 2-poor and 1-bad.

Results and Discussions

Physico-chemical characteristics: Physical and chemical characteristics of the varieties studied are given in Table 1 and 2, respectively.

Tomatoes of most of the varieties were flat to round in shape wherein the diameter was greater than the length (calyx end to stalk end) except *Red Top*. In *Sanmarzano* and *Ruth* the length was greater than the diameter. These three varieties had a characteristic distinct shape of their own, *Red Top* being oblong, *Sanmarzano* pear shaped, and *Ruth* slightly oval. Because of this, they could be easily distinguished from all the other varieties and from one another. The fruit size of *Pusa Ruby*, *Vokal*, *Prosperity*, *Tukon*, *E.C.* 14166, *Tuck Queen*, *Meerti*, and *Turi Alba* was quite big, the average diameter being more than 5.5 cm. The fruit size in all the varieties diminished gradually after fifth plucking. Data in Table 1 show the measurements taken during the first three pluckings. The loculi varied from 2-5 in the individual fruits of the same variety. The wall thickness varied from 4 -7 mm. The core content was lowest in *Ruth* and *Sanmarzano* (0.15 per cent) followed by *Red Top* (0.25 per cent). In other varieties, the core content was more (0.4-0.95 per cent). The peel weight varied from 4 to 6 per cent.

The colour of fruits of *Vokal* variety was crimson or purple red, and hence, this was its distinguishing feature from the red colour of other varieties. *Pusa Ruby*, *Tip Top*, *Red Top*, *Sanmarzano*, *Tukon*, *Poona* 341, *Meerti*, *Turi Alba*, *Type* 9, *Early Chathem* had deep red colour and *Vokal* had deep purple colour. *Pusa Ruby*, *Ruth*, *Turi Alba*, *Type* 9, *Poona* 341, *Early Chathem*, *Red Top*, *Tuck Queen*, *Sanmarzano*, *EC* 14166, *K*-1019 and *Best of All* had uniform colour. In *Tuck Queen* and *Tukon* varieties, the intensity of the red colour was more in peeled fruit than in the unpeeled fruit and it was so to a lesser extent in *Pusa Ruby*, *E.C.* 14166, *Tip Top*, *Money Maker* *Early Chathem*, *Meerti*, *Turi Alba* and *Type* 9 varieties. In *Prosperity*, *Market King* and *Best of All* varieties the colour of the peeled fruit was less as compared to unpeeled one.

Sanmarzano had the lowest acidity (0.33 per cent) while *Meerti*, the highest (0.69 per cent). Brix was highest in *Ruth* (5.23 per cent) and lowest in *Early Chathem* (3.2 per cent). Chemical constituents did not affect the canning behaviour of tomatoes which confirms earlier findings of Asselberg[16] who reported that two varieties of tomatoes having almost the same chemical composition, did not behave similarly on canning.

Cut out results: The results of cut-out analysis are given in Table 3 which represent the average of the values obtained from 2-3 cans opened at a time.

The overall texture of tomatoes of most of the varieties suffered on canning resulting in the softening of tomatoes. Texture in the canned product was better in *Early Chathem*, *Red Top* and *Ruth* varieties. In the varieties *Poona* 341, *Meerti*, *Type* 9, *Turi Alba*, although the initial texture of tomatoes was very firm, on canning they became highly soft, and showed high breakage; the tomatoes were practically mashed in *Meerti* and *Type* 9.

With respect to disintegration of tomatoes, none of the varieties excepting *Red Top* faired well in the case of control lots (Table 3). Addition of calcium chloride as a firming agent, helped in controlling disintegration to varying degrees in different varieties. It has pronounced effect on *Red Top*, *Ruth* and *Prosperity* varieties where in no disintegration was observed in the treated lots. Disintegration was also considerably reduced in *Early Chathem*, *Best of All*, *Sanmarzano*, *K*-1019, *E.C.* 14166 and *Tukon* varieties. In other varieties, the extent of disintegration was very high from 11.4 to 91.4 per cent. The colour of the varieties which showed less breakage under calcium chloride treatment was also good, being red to deep red except in *Prosperity* and *Best of All* varieties, in which case, the colour was poor and unattractive. High disintegration was noticed in the varieties *Pusa Ruby*, *Vokal*, *Poona* 341, *Turi Alba* and *Type* 9, which otherwise had good attributes for canning because of very deep and highly attractive uniform colour. Canning did not affect the colour of tomatoes to any noticeable extent. The can condition was good and practically same in all the varieties. The observations were similar when the cans were examined after 6 and 9 months of storage.

Conclusions: *Red Top* was the top ranking variety for purpose of canning as whole tomatoes and this further confirmed the earlier findings[3]. There was no disintegration even in untreated tomatoes in all the cut-outs. It also had good colour, smooth surface and a small core. Next in order of performance were varieties *Ruth*, *Early Chathem* and *Sanmarzano*. *Prosperity* and *Best of All*, though had less disintegration deteriorated in colour after peeling and hence not satisfactory for canning. In *E. C.* 14166 and *K*-1019, the disintegration was close to the maximum permissible limits. On the whole, the performance of varieties having elongated or

pear shaped tomatoes were better. In these varieties, *Red Top* and *Sanmarzano* were pear shaped and *Ruth* oval shaped and this is in agreement with the findings of earlier workers[14,17].

Acknowledgement

The authors are grateful to Dr B. L. Amla, Director of the Institute and Dr S. Ranganna, Scientist for their keen interest and constructive suggestions in these studies.

References

1. *Fruit and Vegetable Preservation Industry in India-Statistics of Production and Exports*, Directorate of Marketing and Inspection, Nagpur, 1972.
2. Cruess, W. V, *Commercial Fruit and Vegetable Products*, McGraw Hill Book Co. Inc, New York, 1958
3. Beerh, O. P. and Bhatnagar, H. C., *Indian Fd Pckr*, 1962, **16** (6), 11.
4. Duran, L. and Roig, A. R., *Revta Agroquim. Technol. Aliment.*, 1962, **2**, 8.
5. Duran, L., Cunat, P., Flores, J., Morell, J. and Plaja, S.Y., *Revta Agroquim Technol. Aliment.*, 1964, **4**, 351.
6. Duran, L., Cunat, P., Morell, J., Flores, J. and Sanchez, J., *Revta. Agroquim. Technol. Aliment.*, 1965, **5**, 112.
7. Taboada, M.C.D., *Revta Agroquim. Technol. Aliment.*, 1967, **7**, 248.
8. Cooler, F. W., Camper, H. M., Jr. and Scott., F. H., *Res. Rep. Va agri. Exp. Stn*, 1964, **79**, 12 (*Hort. Abs.*, 1965, **35**, 1206).
9. Korbonits, A., *Konzerv-es paprikaipar*, 1955, Aug., p. 9 (*Hort. Abs.*, 1957, **27**, 516).
10. La Rotonda, C., *Ann. Fac. Sci. agrar. Univ. Napoli*, 1956/57, **22**, 221 (*Hort. Abs.*, 1958, **28**, 1503).
11. Lyall, H. H., *Canada J. Plant Sci.* 1962, **42**, 539.
12. Tuza, S., *Konz. Paprikaipar*, 1962, No. 5, 171 (*Hort. Abs.*, 1964, **34**, 4992).
13. Jain, N. L. and Mukherjee, S. K., *Indian Hort.*, 1966, **10**, 51.
14. Roy, S. K., Murali Krishna, M., Tewari, R. N., Ray Choudhuri, M. and Choudhury, B., *Indian Fd Pckr*, 1970, **24** (6), 11.
15. *Official Methods of Analysis*, A.O.A.C. Washington, 4 DC. 1975.
16. Asselbergs, E.A.M., *Rep. Canad. Cttce Fruit Veg. Preserv. for* 1956, 1957, p. 11. (*Hort. Abs.*, 1958, **28**, 480).
17. Bigelow, W. D., Smith, H. R., and Greenleaf, C.A., *Tomato Products*, National Canners Ass. Res. Lab, Washington D.C. 1950, p. 3.

Effect of Addition of Formalin and Storage on Chemical Composition of Paneer

K. B. HARIDAS AND K. M. NARAYANAN
National Dairy Research Institute, Karnal, India.

Manuscript Received: 26 *February* 1976

***Paneer*, an acid coagulated milk product, could be preserved well for 6 days with the addition of 0.4% (V/W) formalin for carrying out further analysis. On further storage it became mouldy and decreased in fat and total nitrogen content and increased in water, soluble nitrogen, tyrosine and acidity.**

Rule 19 of the Prevention of Food Adulteration Rules, 1955[1] permits a food inspector to add a preservative as may be prescribed from time to time to the sample for purposes of maintaining it in a condition suitable for analysis. Rule 20 prescribes the names of foods to which formalin can be added, but *Paneer* which is an acid coagulated perishable milk product does not find a place. It is not known how long *Paneer* could be preserved by addition of formalin without changing its composition; a study on this aspect was carried out.

Materials and Methods

Ten separate batches of *Paneer* prepared at the Experimental Dairy of the Dairy Technology Division, National Dairy Research Institute, Karnal were collected for the investigation. They were individually mixed well with 0.4 per cent (v/w) formalin (about 40 per cent w/v formaldehyde solution) and stored in clean sterile 125 ml stoppered glass bottles at 30°C in dark. In each batch, sufficient number of samples were stored so that at each time of analysis separate sample could be taken for investigation. A set of control samples were also stored without adding formalin. At regular intervals, both control and preserved samples of each batch were checked for their general condition (such as mouldiness) and analysed at random. The samples after making up the volume by adding distilled water for any loss in weight were analysed for acidity[2], moisture fat,[3] soluble and total nitrogen[4] and tyrosine[5]. The physico-chemical constants of the extracted fat were also determined[6].

Results and Discussion

The moisture and fat (on wet basis) contents of the *Paneer* samples varied from 50.3 to 55.6 per cent (average 52.6 per cent) and 24.3 to 28.5 per cent (average 26.2 per cent), respectively and they were within the limits of chemical standards prescribed for *Paneer*.

The effects of addition of 0.4 ml per cent formalin and the chemical composition of *Paneer* are shown in Fig 1. During the storage period no mould growth was observed in the *Paneer* samples for a period of 5-6 days after which they became mouldy and putrid. The average acidities (expressed as lactic acid per cent) of the samples for storage periods of 0, 6, 7, 14 and 21 days were 0.55, 0.55, 0.57, 0.61 and 0.66 respectively. From Fig. 1 it is seen that there were no appreciable changes in the chemical composition studied for a storage period of 6 days. However, on subsequent storage there was decrease in fat and total nitrogen contents, and increase in water-soluble nitrogen, tyrosine and acidity. The percentage decrease in fat content of the preserved sample for storage periods of 7,14 and 21 days varied from 0 to 1.8 (average 1.0), 2.4 to 5.7 (average 3.9) and 5.4 to 9.0 (average 7.1) respectively. These decreases in fat contents may be due to lipolysis of fat. The percentage decreases in the total nitrogen for the corresponding periods varied from 0 to 5.0 (average 2.1) 2.6 to 11.9 (average 6.3) and 4.1 to 14.3 (average 8.0) respectively. The percentage increases in water soluble nitrogen contents of the preserved samples for storage

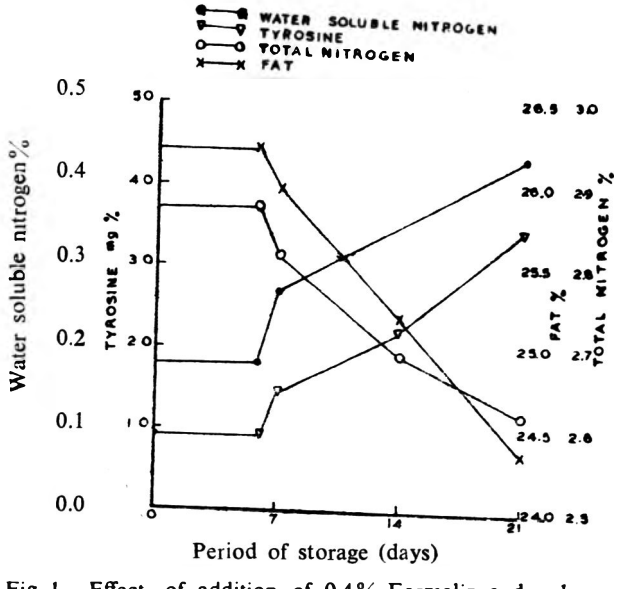


Fig. 1. Effect of addition of 0.4% Formalin and subsequent storage on composition of *Paneer*.

TABLE 1. EFFECT OF ADDITION OF FORMALIN ON PANEER AND SUBSEQUENT STORAGE ON THE PHYSICO-CHEMICAL CONSTANTS OF THE EXTRACTED FAT

Physico-chemical constants.	Storage days	
	0	8
Reichert value	31.1	30.9
Polenske value	1.4	1.4
Iodine value	33.9	33.7
Butyro-refractometer reading (40°C)	42.5	40.7

periods of 7,14 and 21 days varied from 0 to 100 (average 50) 50 to 200 (av. 89) and 100 to 250 (av. 150) respectively. The corresponding increases in the tyrosine contents of the samples varied from 0 to 130 (average 56), 104 to 210 (average 138) and 168 to 494 (average 273) respectively. These increases in water soluble nitrogen and tyrosine contents may be due to proteolytic changes taking place in the materials during storage.

Since significant changes took place in the fat contents of the preserved *Paneer* samples after a storage period of 8 days, it was necessary to study the changes in the physico-chemical constants of their extracted fat. The results are shown in Table 1. From this it is seen that there were only slight changes in the physico-chemical constants of the fats.

The control samples of *Paneer* (without preservative) showed considerable mould growth during a storage period of 2-3 days and decrease in fat and total nitrogen, and increase in water-soluble nitrogen, tyrosine and acidity. A comparison of these data with those observed on preserved samples showed that addition of formalin at the rate of 0.4 ml per cent is beneficial to increase their storage period from 2 to 6 days.

References

1. *Prevention of Food Adulteration Rules*, 1955 (*as amended till February*, 1974), Ministry of Health, Government of India.
2. *Specification for Ice-cream, IS:* 2802-1964, Indian Standards Institution, New Delhi, 1964.
3. *Specification for Hard Cheese, Processed Cheese and Processed Cheese Spread, IS:* 2785-1964. Indian Standards Institution, New Delhi, 1964.
4. *Official Methods of Analysis*, Association of Official Analytical Chemists, 11th Ed. Washington, D.C. 1970.
5. Hull, M. E., *J. Dairy Sci.*, 1947, **30**, 881.
6. *Methods of Sampling and Test for Ghee* (*Butter fat*), *IS:* 3508-1966. Indian Standards Institution, New Delhi, 1967.

Colorimetric Estimation of Sucrose in Ice-Cream

P. C. Pantulu, J. Sebastian, V. Unnikrishnan and M. Bhimasena Rao
National Dairy Research Institute, Bangalore, India

Manuscript Received: 17 *November* 1975

A simple colorimetric method based on Seliwanoff reaction has been developed for quantitative estimation of sucrose in ice-cream. The method comapred well with the standard copper reduction method.

The estimation of sucrose in milk products like ice-cream, sweetened condensed milk, khoa and others is usually made by the classical Lane-Eynon or Munsen Walker or polarimetric method, after de-proteinization of the test sample. The colorimetric methods for the estimation of reducing sugars are based on the reduction of alkaline solution of copper to cuprous oxide and its reaction with phospho-molybdic acid[1] or on the reduction of picric acid to picramate. These methods have also been adopted to estimate sucrose after hydrolysis. Willaman and Davison[2] used this method for the determination of glucose and sucrose in corn syrup and after modification for the simultaneous determination of lactose and sucrose in dairy products by Perry and Doan[3]. Garcglio and Stella[4] used diphenyl amine reaction and chloroform extracts of the colour to estimate sucrose in milk Colorimetric estimation of lactose and sucrose in milk and its products using 3,6-dinitrophthalic acid was carried out by Mamose and Mukai[5]. Birch and Mwangelwa[6] developed a colorimetric method using phenol-sulphuric acid for the determination of lactose and sucrose in condensed milk products. Sucrose in ice-cream and frozen milk could also be estimated by iodometric methods[7]. So far the Seliwanoff reaction which used to distinguish a ketose from an aldose has not been applied to the quantitative determination of sucrose in dairy products. Since dairy products like ice-cream contain added sucrose and the lactose present is not responsive to the Selliwanoff reaction, a simple colorimetric method using resorcinol for the estimation of added sucrose has been described here.

Materials and Methods

The method consists of heating deproteinised filtrate of ice-cream with resorcinol in concentrated hydrochloric acid and measuring the colour using a colorimeter. The maximum absorbance is at a wavelength of 490 mμ (Fig 1). The exact chemical nature of the coloured chemical compound formed is not known.

An accurately weighed quantity of ice-cream (about 10 g) was made up to 250 ml with distilled water along with four or five drops of a solution of lead acetate (40 per cent w/v) in water, to precipitate the proteins. A slight excess of lead acetate did not affect the results. A suitable aliquot of the protein-free filtrate was taken in a test tube of 15 cm $\times$ 1.5 cm, and heated with 0.1 per cent resorcinol (2 ml) and concentrated HCl (6 ml of 12 N solution) for different durations and temperatures to develop the colour.

Effect of concentration of acid: The quantity of concentrated HCl used was according to Allport and Keyser[8].

Effect of concentration of resorcinol: Slight changes in volume of 0.1 per cent resorcinol had no effect on the colour intensity.

Stability of colour: The colour remained stable even up to three hours. Storage over a period of one week under refrigerated condition gave reproducible results, whereas samples kept outside at room temperature gave lower results besides developing mouldy growth. Similarly the protein-free extract could be stored under refrigeration for later development of colour.

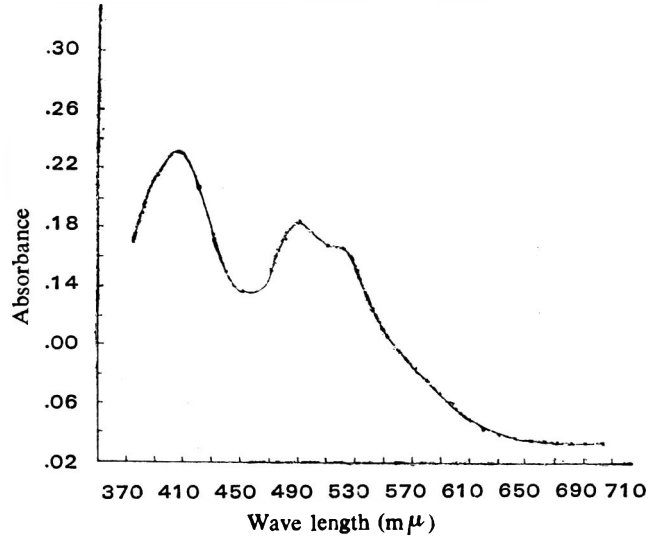


Fig. 1. Absorbance spectra of the resorcinol colour complex

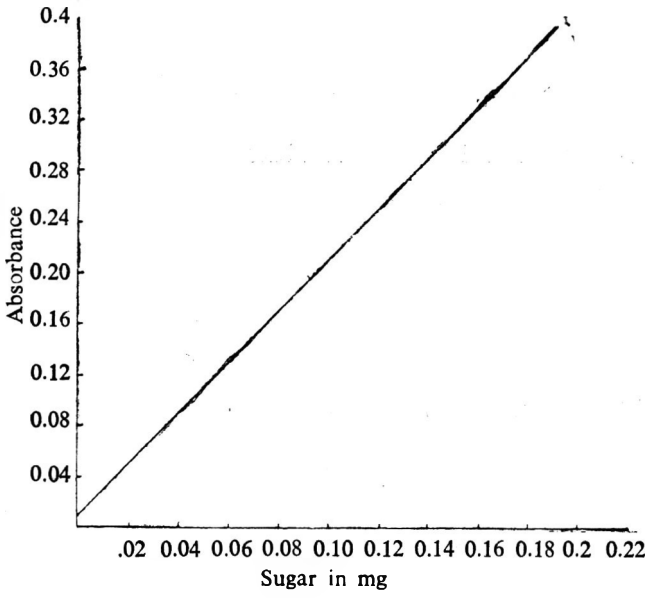


Fig. 2. Standard curve for sucrose

Effect of non-protein nitrogenous compounds: Addition of urea at 2 per cent level did not interfere with the intensity of colour.

Recovery experiments: Trials on recovery of added sugar to ice-cream were made and a slightly higher value of 103 per cent recovery was found. The standard prepared with sucrose (B.D.H. Analar) indicated that Beer's Law is obeyed when the concentration of sucrose in the test solution is upto 0.2 mg (Fig 2). The samples of ice-cream prepared for the test should not exceed this limit; the sucrose of the test filtrate of ice-cream has been diluted to bring down its concentration well within this limit as described in the procedure. An ice-cream sample containing the maximum permitted sucrose content of 15 per cent will thus have in the final test sample 0.12 mg sugar.

TABLE 1. SUCROSE CONTENT OF ICE-CREAM AS DETERMINED BY STANDARD LANE-EYNON METHOD AND RESORCINOL METHOD

Sample No.	Sucrose %	
	Lane-Eynon	Resorcinol
1	14.90	15.62
2	15.68	15.69
3	14.74	14.50
4	15.57	15.13
5	15.94	15.56
6	14.64	14.75
7	15.02	14.88
8	14.29	14.75
9	13.55	13.88
10	14.80	14.19
11	14.90	14.75
12	13.30	13.88
13	10.52	11.00
14	14.69	15.37
15	14.74	15.50
16	14.90	15.50
17	15.49	15.50
18	14.66	14.00
Mean	14.57	14.69

TABLE 2. PRECISION OF THE RESORCINOL METHOD

Replicate	Sucrose %	Difference (d)	Difference (d^2)
1	15.50	+0.051	0.002601
2	15.69	-0.139	0.019321
3	15.63	-0.079	0.006241
4	15.81	-0.259	0.067081
5	15.50	+0.051	0.002601
6	16.00	-0.449	0.201601
7	15.25	+0.301	0.090601
8	15.50	+0.051	0.002601
9	15.38	+0.171	0.029241
10	15.25	+0.301	0.090601
Mean	15.551		
S.D.		0.24	

The sucrose content of 18 samples of commercial ice-cream was determined both by Lane-Eynon volumetric method and the resorcinol colorimetric method described here (Table 1). The differences in the values estimated by these two methods were not significant.

The precision of the resorcinol method was determined by estimating ten replicates of the same sample by the method. The reproducibility of the values are given in Table 2. The replicate estimations indicated a standard deviation of 0.24 which is satisfactory for routine analysis.

References

1. Folin, O. and Wu, H., *J. biol. Chem.*, 1920, **41**, 367.
2. Willaman, J. J. and Davison, F. R., *J. agric. Res.*, 1924, **28**, 479.
3. Perry, N. A. and Doan, F. J., *J. Dairy Sci.*, 1950, **3**, 176.
4. Garoglio, P. G. and Stella, C., *Mondood Latte*, 1963, **17**, 295.
5. Mamose, T. and Mukai, Y., *J. Pharm. Soc. Japan*, 1961, **81**, 227.
6. Birch, G. G. and Mwangelwa, P. M., *J. Sci. Fd Agric.*, 1974, **25**, 1355.
7. *Australian Stand. No.* 72, Standards Association of Australia. 1970, 33.
8. Noel L. Allport, and Keyser J. W., *Colorimetric Analysis*, Champman and Hall Ltd., London, 1957, Vol. I., 146.

Laboratory Evaluation of Tablets and Strips of Juvenile Hormone Analogue Altozar[R] for the Control of *Trogoderma granarium* Everts

PREM LATA BHATNAGAR-THOMAS
Biology and Agriculture Division, Bhabha Atomic Research Centre, Trombay, Bombay 400085, India

Manuscript Received: 27 *January* 1976

Pesticidal activity of Altozar[R], a juvenile hormone analogue (JHA), was evaluated using khapra beetle (*Trogoderma granarium* Everts) as a test insect. JHA (0.1ppm) when mixed in the food was effective in inhibiting the metamorphosis of normal and diapausing larvae but 0.5 ppm was required for arresting the metamorphosis of young female pupae.

JHA (0.1 ppm) adsorbed on chalk tablet and filter paper strip when introduced into semolina experimentally infested with insects was also sufficient for controlling the development for normal and diapausing larvae. For young pupae, paper impregnated with 1.0 ppm and tablet with 1.5 ppm of JHA were required. JHA either mixed in the diet or adsorbed on chalk tablets or filter paper strips retains its biological activity for over six-months. It is suggested that tablets or strips containing JHA may be employed for protecting stored grain products from insect infestation with minimal hazard of residual contamination.

Potentiality of juvenile hormone analogues (JHA) as protective agents against insects infesting stored grain and grain products has been demonstrated[1-5]. Ability of JHA to protect commodities from reinfestation by insect pests was found to compare satisfactorily with common grain protectants such as pyrthrins[3,6]. Usual procedures employed by various workers involve spraying or mixing the food with the hormonal analogue solution in organic solvents[1,3,5], or mixing with dust formulations[7]. Eventhough, these methods are highly effective in controlling insect infestations, they are unlikely to find commercial application because of the introduction of residual contamination in the stored foods. These problems can be minimized if JHA can be introduced into the storage bins in the form of tablet(s) or strip(s) which can be removed when desired. Such a possibility has been explored in the laboratory using the JHA, Altozar[R], ethyl (2E, 4E)-3, 7, 11-trimethyl 2, 4-dodecenoate, as the test chemical and khapra beetle (*Trogoderma granarium* Everts) as the test insect and the results are presented in this paper.

Materials and Methods

For the preparation of tablets 0.3 ml acetone containing 10 to 150 μg of Altozar[R] was carefully pipetted over 1 cm$\times$0.5 cm cylindrical chalk pieces and left at room temperature for 4 to 6 hr for the solvent to evaporate. Control tablets were prepared in a similar manner, without the JHA.

JHA impregnated circular strips were prepared by applying 1.5 ml acetone containing 10 to 150 μg of JHA to a 5 cm diameter Whatman No. 1 filter paper. A similar paper in which 1.5 ml of acetone alone was applied served as the control. Following evaporation of the acetone, the circular paper strips or the tablets were introduced into 6 cm$\times$10 cm containers containing 100 g of semolina experimentally infested with 18-day old larvae, hereafter referred to as "normal larvae", 75 day old diapausing larvae and 0-4 hour old female pupae. Diapause was induced by overcrowding of the last instar larvae at 34$\pm$1°C. These stages were selected as they were earlier shown to be susceptible to JHA action[8]. Similarly infested semolina mixed with 10 to 150 μg of JHA dissolved in acetone[1] served as the standard. The dosage of JHA was calculated in relation to the quantity of food used and is expressed as parts per million (ppm) in the food.

All the experiments were carried out at 34$\pm$1°C and 50$\pm$5 per cent R. H. Each dose treatment was replicated four times with 100 larvae/pupae per replicate. Emergence of adults/intermediates (larval-pupal or pupal-adult[8]) was scored daily till all the larvae or pupae completed either their normal or abnormal metamorphosis.

Results

Pesticidal activity of Altozar mixed in the diet: To test the pesticidal activity of Altozar by the conventional standard method[1], larvae and pupae of khapra beetle were reared on semolina mixed with 0.1, 0.2, 0.3, 0.4 and 0.5 ppm of JHA.

Normal larvae were unable to complete their meta-

morphosis even at 0.1 ppm, the lowest test concentration of JHA (Fig. 1A). They developed into larval-pupal intermediates within 21.75 days as compared to the control larvae which emerged as fully developed, normal adults within about 15.5 days of the experiment. At concentrations of 0.2, 0.3, 0.4 and 0.5 ppm of JHA in the diet, it took 27.25, 31.25, 33.0 and 35.50 days respectively before all the larvae emerged as intermediates (Fig. 1A).

In case of diapausing larvae the diapause was terminated by releasing them into fresh semolina as such or semolina mixed with 0.1 ppm or higher levels of JHA (Fig. IB). Here also the larvae failed to develop into normal adults even at 0.1 ppm; they emerged as larval-pupal intermediates. In comparison to the control where all the larvae developed into adults within about 19 days, the period for the emergence of 100 per cent of the larvae into intermediates on diets treated with 0.1 to 0.5 ppm of JHA was much longer and varied from 32 to 66 days respectively (Fig. 1B).

When 0-4 hr old female pupae were subjected to a similar treatment, a dose-dependent inhibition of metamorphosis was observed with 100 percent inhibition at 0.5 ppm level of JHA in the diet (Fig. 2). The percentage of pupal-adult intermediates increased from 18 at 0.1 ppm to 95 at 0.4 ppm, while that of adults showed a corresponding decline from 82 to 5. Except at 0.4 ppm in the diet, where the adults obtained were abnormal and sterile, at all the lower dose levels they were normal and fertile.

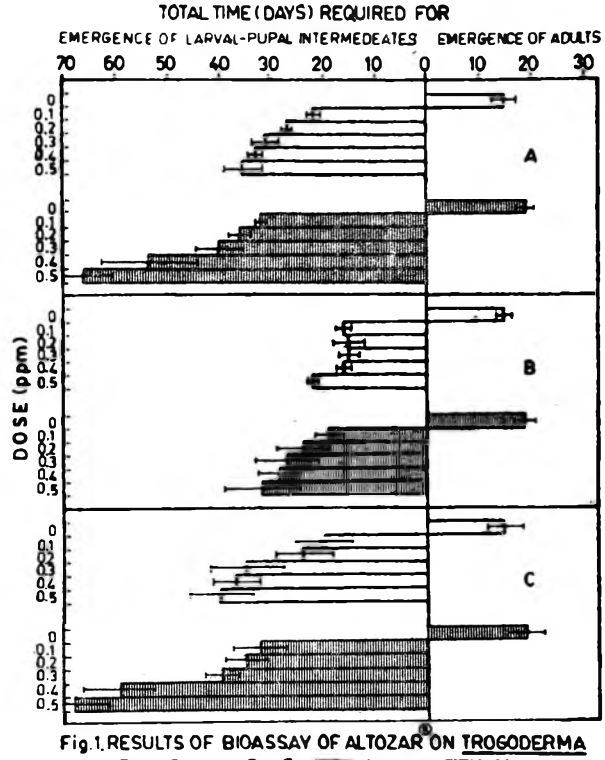


Fig.1. RESULTS OF BIOASSAY OF ALTOZAR ON TROGODERMA GRANARIUM LARVAE: Normal, Diapausing. A-JHA mixed diet; B-JHA Tablet; C-JHA strip.

Pesticidal activity of Altozar tablets and paper strips in the diet: With JHA tablets in infested semolina (Fig. 1B) none of the normal larvae emerged as adults, but they developed into larval-pupal intermediates in about 16 days at 0.1 to 0.4 ppm JHA and in about 22 days at 0.5 ppm as compared to 100 per cent adult emergence in about 15 days in the control.

Paper strips impregnated with JHA were also effective in arresting the development of normal larvae (Fig. 1C). However, in comparison to the treatment with JHA tablets, the time taken by all the larvae to develop into larval-pupal intermediates was much longer.

Diapausing larvae also failed to metamorphose in the presence of 0.1 to 0.5 ppm of JHA tablets as well as paper strips (Fig. 1B and C). As compared to the control where 100 per cent adults emergence was observed within 19 days of experiment, the period for the emergence of 100 per cent larval-pupal intermediates on 0.1 0.2, 0.3, 0.4 and 0.5 ppm JHA tablets (Fig. 1B) was 19, 24, 27, 28 and 32 days respectively. On JHA strips (Fig. 1C) of identical concentrations however the corresponding periods were 32, 35, 39, 59 and 68 days respectively.

JHA tablets and paper strips were also effective in arresting the metamorphosis of 0-4 hr old female pupae (Fig. 2). However, doses of 1.0 and 1.5 ppm of JHA were required respectively when strip and tablet were used for achieving complete inhibition of metamorphosis. At lower concentrations a mixed population of adults and pupal-adult intermediates was recorded. The adults obtained at and above 0.5 ppm JHA concentration whether as tablets or strips were sterile.

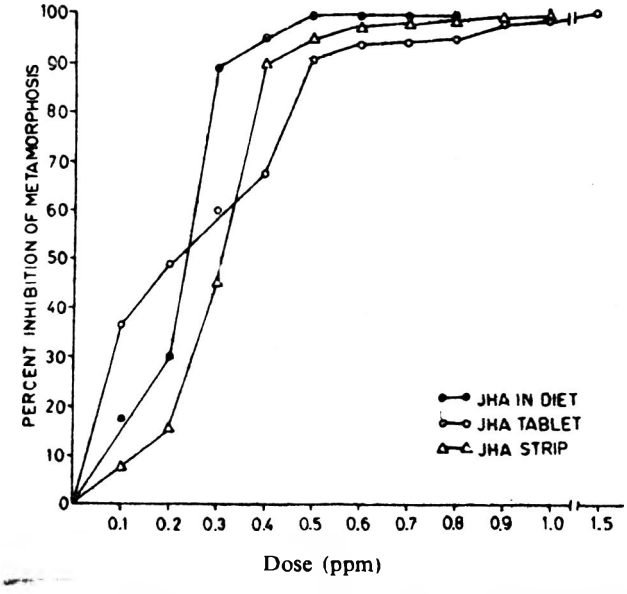


Fig. 2. Results of bioassay of Altozar on 0-4 hr old female pupa of *Trogoderma granarium* Everts.

Stability of Altozar tablets and strips: Tablets and strips of Altozar prepared as described earlier were stored in closed high density polythene containers for about six-months at 34±1°C and 50-60 per cent R.H. Pesticidal activity of these stored tablets and strips was assessed against normal khapra beetle larvae and the results were more or less similar to the ones obtained with freshly prepared samples (Fig. 1B and C) indicating that tablets and strips retain most of the JHA activity even after six months of storage. Preliminary studies also indicated that JHA tablets and strips stored for six-months were equally effective in arresting metamorphosis of *Tribolium castaneum.*

Discussion

Earlier studies[8] on khapra beetle have shown that at 34±1°C a concentration of 20 ppm of ethyl farnesoate in the diet was sufficient to arrest the metamorphosis of normal as well as diapausing larvae, while for young pupae a dose of 300 ppm was required to achieve the same effect.

Present studies indicate that Altozar is several fold more active than ethyl farnesoate and a concentration of 0.1 to 1.5 ppm in stored food would be sufficient to protect it from khapra beetle infestation. Further, JHA adsorbed on inert materials such as chalk and cellulose retains most of its activity for several months. It is possible that environmental factors viz., light, U.V. rays, moisture, etc., which are generally responsible for the rapid degradation of JHA in the field[10] may not be operating under the laboratory conditions in which these were stored. It is, therefore, suggested that the JHA tablets or strips can be used for the control of khapra beetle and other pests of stored grain products such as *Tribolium castaneum* without the risk of residual contamination. Moreover, JHA tablets appear to have added advantage over the other methods of JHA application inasmuch as the larval diapause is terminated comparatively earlier and the life-span of normal larvae of khapra beetle is also not prolonged significantly[8,9]. This is of great importance as the larvae are known to feed intermittently during facultative diapause[8,11] and thus contribute to increased food losses.

Preliminary studies carried out in the laboratory further indicate that tablets containing higher concentration of JHA are required when the insects were tested in larger containers with same quantity of semolina. Effective JHA dose for bulk food commodities, therefore, needs to be ascertained together with alternate adsorbants and easier and practical method(s) of impregnation of JHA in inert media.

Acknowledgement

I thank Dr. G. B. Staal, Zoecon Corporation, U.S.A. for the generous gift of Altozar[R].

References

1. Thomas, P. J. and Bhatnagar-Thomas, P. L., *Nature, Lond.*, 1968, **219**, 949.
2. Bhatnagar-Thomas, P. L., *J. econ. Entomol.*, 1973, **66**, 277.
3. Slama, K., Romanuk, M. and Sorm, F., *Insect Hormones and Bioanalogues*, Springer-Verlag Wien, New York, 1974, 470.
4. Bagley, R. W. and Bauernfield, J. C., in *Insect Juvenile Hormones Chemistry and Action*, Menn, J. J. and Beroza, M., Academic Press N. Y., 1972, 113.
5. Strong, R. G. and Diekman, J., *J. econ. Entomol.*, 1973, **66**, 1167.
6. Bhatnagar-Thomas, P. L., unpublished.
7. Hoppe, T., *J. econ. Entomol.*, 1974, **67**, 789.
8. Bhatnagar-Thomas, P. L., *Indian J. Entomol.*, 1972, **34**, 87.
9. Bhatnagar-Thomas, P. L., *J. Fd Sci. Technol.*, 1975, **12**, 237.
10. Pawson, B.A., Scheidl, F. and Vane, F., in *Insect Juvenile Hormones Chemistry and Action*, Menn, J. J. and Beroza, M., Academic Press Inc. N. Y., 1972, 191.
11. Burges, H. D., *Bull. ent. Res.*, 1959, **50**, 407.

RESEARCH NOTES

CHANGE OF pH IN PICKLED QUAIL EGG AT ROOM TEMPERATURE

The changes in pH of pickle solution, white and yolk components of hard boiled quail eggs, pickled in commercial vinegar were studied. The pickle solution white and yolk attained equilibrium at pH 3.9 within 4 days. The pH declined rapidly in egg white and slowly in yolk.

Pickling of quail egg was first initiated by Panda[1], at the Indian Veterinary Research Institute with a view to preserve whole eggs at room temperature, so that these eggs could be transported without refrigeration to different parts of the country, to extend animal protein supply to the vulnerable group of the society. Subsequently, Rao and Panda[2] developed formula for pickling of quail eggs. Only limited information is available concerning the factors affecting the quality of these pickled eggs. Work on pickling of chicken eggs has been reported by Act on and Johnson[3], Bal and Saffores[4] and McCready[5]. The authors have not come across in the published literature any detailed work on qualitative studies of pickled quail eggs. The present work was undertaken to study the changes of pH in pickling solutions and hard boiled eggs of quail egg pickle.

Fresh quail eggs obtained from IVRI Poultry Farm were properly washed, hard boiled for 20 min in boiling water, cooled to room temperature and hand peeled. The pickling solution was prepared by commercial vinegar and distilled water at the ratio of 1:2 with spices and condiments.[2] 140 quail eggs kept in two plastic containers, were completely dipped in pickle solution, at room temperature. The pH of pickle solution, separated white and yolk from four hard boiled eggs was determined at 0, 2, 4, 6, 8, 10, 12 hr and on 1, 2, 3, 4, 5, 8, 10, 13 and 15 days from the two containers using Beckman pH meter. Yolk and white samples were blended with 5 times their weight of distilled water for pH measurements.

The change in pH of quail egg components and pickle solution during the 15 days period is presented in Fig. 1.

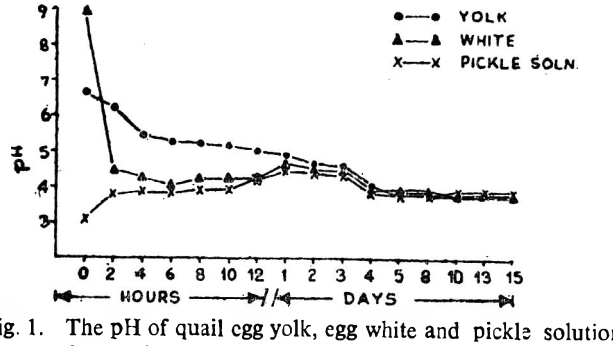


Fig. 1. The pH of quail egg yolk, egg white and pickle solution during different pickling intervals

The pH of yolk declined slowly from an initial pH of 6.7 to final equilibrium pH of 3.9 in 4 days, whereas the pH of white declined rapidly from an initial value of 8.9 to the equilibrium in 12 hr. The pH of pickle solution gradually increased from initial 3.15 to final 3.9 in 4 days. The pH of white, yolk and pickle solution remained unchanged at 3.9 beyond 4 days. The decrease of pH in egg white, yolk and the increase in pH of pickle solution is due to diffusion of acetic acid from pickle solution to the white and yolk. However, the stabilization period depends upon the initial concentration and the diffusion rate of acetic acid from pickling solution medium to egg white and yolk.

Poultry Research Division,
Indian Veterinary Research Institute,
Izatnagar, U.P.
26 *December* 1975.

A. K. SRIVASTAV
B. PANDA

References

1. Panda, B., Unpublished data, 1974.
2. Rao, K. N. and Panda, B., *Indian J. Poult. Sci.*, 1975. **19**, 195 (abstract).
3. Act on, J. C. and Johnson, M. G., *Poult. Sci.*, 1973, **52**, 107.
4. Ball, H. R., Jr. and Saffores, M. W., *Poult. Sci.*, 1973, **52**, 916.
5. McCready, S. T., *Poult. Sci.*, 1973, **52**, 1310.

STORAGE STABILITY OF EGG POWDER IN FLEXIBLE POUCHES

Flexible pouches made out of paper/.04 mm aluminium foil/ 150 gauge polyethylene have been found suitable for gas packaging of egg powder and ensuring a shelf-life of minimum 1 year. Three ply corrugated board folder cover by way of protective packaging ensures the integrity of the pouches during transportation, handling and storage.

Egg powder is a service ration item issued to troops posted at high altitude areas. The item is currently produced in commercial quantity in the country by spray drying method and is governed by an I S I specification[1] which requires that the product should be packed in tin containers or flexible containers under nitrogen gas. The Army supply corps specification largely follows the IS specification but differs mainly in respect of solubility requirement which should be a minimum of 85 per cent when determined by Haennis' method[2]. It is well known that for reasons of logistics, Army favours flexible packaging as far as possible. It was therefore considered necessary to devise a flexible pack which could be adopted immediately in terms of the existing specification and which could also ensure a minimum shelf life of 1 year to be of use to

TABLE 1. STORAGE STUDIES OF EGG POWDER IN FLEXIBLE POUCHES AT DIFFERENT FIELD LABORATORIES

Part culars of test	Places and periods (months) after which tested									Initial values
	Jodhpur			Tezpur			Leh			
	6m	9m	12m	6m	9m	12m	6m	9m	12m	
O_2 inside pouch (%)	1.5	1.1	1.7	*	**	2.1	2.0	1.5	*	1.1 to 2.0
	1.0	1.5	1.8	*	**	2.6	2.5	0.5	*	"
Moisture (%)	1.65	2.0	1.6	—	1.6	1.7	1.9	1.9	—	0.87
Solubility (%)	97.0	95.3	95.3	—	95.3	95.3	95.3	95.3	—	97.00
Organoleptic rating	Like very much			Like moderatly			Indifferent			

*Samples and report not received. **Couldnot be determined. m = Months.

the Services. Previous work on consumer packing of egg powder in flexible pouches[3,4] did away with gas packaging and aimed either at a shorter shelf life or used a technique, viz. compression into blocks, that cannot be readily adopted on a large scale.

A flexible pouch pack, like the tin container, must retain the nitrogen gas during the whole storage period and the oxygen concentration in the package atmosphere must remain low — 2 per cent or less. Earlier work[5] in this laboratory has shown that 0.04 mm foil laminate is completely impermeable to moisture and oxygen, and hence this was used for making flat pouches in sizes which could hold 50 to 100 g (size of the pouch 17 × 15 cm for 50 g; 20 × 18 cm for 100 g) of the product without excessive bulging. Flushing with nitrogen gas was done under standardised conditions. Filled pouches were kept in a vacuum desiccator which was evacuated to a vacuum of 27 in. mercury and then the vacuum was released with nitrogen. This was repeated twice, and then the pouches were heat sealed quickly. On repeated checking with the help of Beckman polarographic oxygen analyser it gave an oxygen concentration between 1 and 2 per cent inside the pouches. For giving protection against physical damage in course of handling, storage and transportation, two such pouches were provided with a 3 ply corrugated board folder cover closed by gum tape. The flexible pouches enclosed in folder covers were repacked in plywood cases and stored at Jodhpur, Tejpur (Assam) and Leh under ambient conditions in covered sheds free from rodents. Packs taken out at random every three months were sent back to Mysore for tests and at the same time some of them were issued to the army personnel consisting of 20 to 27 men for organoleptic ratings which was done as follows: like very much; like moderately; indifferent; dislike moderately; dislike very much.

At Mysore the packs were examined for oxygen concentration, moisture content by ISI method[1] and solubility of the product by Haenni's method[2]. Results presented in Table 1 show that the packs retained nitrogen gas with low oxygen concentration throughout the storage period. The product also maintained its low moisture content and high solubility during the period of storage at all the three places. Organoleptic rating varied from place to place but at no place they were unacceptable. The experiments indicate that given suitable protective packaging a flexible pack initially completely impermeable can retain its integrity throughout its period of storage despite handling and transportation. The flexible pack devised for egg powder conforms to the requirements of specification and is of practical value not only for Defence purpose but also for the general consumer market. Using paper/.04 mm foil/150 G polyethylene laminate and a pack size of 100 g the cost of packaging including the outer protective folder is found to be comparable to that of a A $2\frac{1}{2}$ can containing 350 g.

Defence Food Research Laboratory,
Jyothinagar,
Mysore-10.
N. NIRMALA
K. G. GHOSH
T. R. SHARMA

29 *January* 1976.

References

1. *Specification for Egg Powder*, IS: 4723-1968, Indian Standards Institution, New Delhi.
2. Hawthorne, J.R., *J. Soc. chem. Ind. Lond.*, 1943, **62**, 135.
3. Langer, S. S., Anandaswamy, B. and Balasubramanyan, N., *J. Fd Sci. Technol.*, 1973, **10**, 101.
4. Srivastava, M. P., Nirmala, N. and Bhatia, B. S., *J. Fd Sci. Technol.*, 1973, **10**, 112.
5. Ghosh, K. G., Sripathiachar, K., Srivatsava, A. N., Ramanujam, S., Kameshwara Rao, G. and Vijayaraghavan, P. K., *J. Fd Sci. Technol.*, 1968, **5**, 12.

BOOK REVIEWS

Principles of Food Science: Edited by Owen R. Fennema, *Part II. Physical Principles of Food Preservation*: Marcus Karel, Owen R. Fennema and Daryl B. Lund, Marcel Dekker, Inc. New York and Basel, 1975, pp. 474.

The book under review forms one of the three heads under which the subject of Principles of Food Science is proposed to be discussed in a series of monographs. As stated by the authors in the preface, the purpose of bringing out this volume is primarily to provide university level students with a text book on the subject in the absence of any at present. From a review of the publication it appears that the authors have largely succeeded in achieving their objective.

The subject matter has been aptly divided into the following four parts: (*i*) preservation through energy input; (*ii*) preservation through temperature reduction; (*iii*) preservation through water removal; and (*iv*) preservation through storage by packaging.

The introductory chapter deals with the expanding world population and the importance of increasing food production as well as preservation in the context of feeding the hungry millions. With increasing population, food sources and supplies are continuously strained. This has naturally resulted in greater emphasis on the efficient management of raw materials and better processing technology requiring more qualified personnel not only to handle the existing technology but also to search for newer and better methods of food preservation.

The second chapter on "Heat transfer in foods" describes the various principles and theories involved in heat transfer in foods by conduction, convection and radiation. It also includes a short reference to microwave heating and dielectric heating.

The third chapter exhaustively deals with heat processing. It particularly explains various factors involved in heat penetration, methods of determining lethality in thermal processing and recent developments therein. The author has explained the phenomena of heat processing at great length and has taken pains in documenting the entire write up with relevant tables and figures. The importance of this data bank can hardly be over emphasised keeping in view the fact that a major portion of the total volume of food preservation in the world at present is through heat processing.

In chapter IV the radiation preservation of foods which is potentially very important and which is sure to acquire greater role in the years to come has been dealt with. After a vivid description of properties, chemical effects and effects on living organisms of ionizing radiation, technological aspects of radiation processing are fully explained with particular reference to stabilization of army rations and other selfstable foods.

Chilling and freezing, the two important methods of food preservation are presented in the next two chapters. These two focus attention on temperature, humidity, controlled atmosphere and changes that take place in various food materials under cold temperature storage. The chapter on freezing discusses super-cooling, crystallisation, tissue damage and formation of ice crystals. Types of crystallisation have been given particular attention to stress its importance.

Since the most important technique of food preservation is dehydration, the author has rightly provided one complete chapter on equilibrium and rate concentration before discussing methods of water removal. In the succeeding chapter on water activity, the author has brought out lucidly the importance of the concept of water activity vis-a-vis food preservation. The application of lowering of water activity to food preservation is given in three chapters, viz., concentration, dehydration and freeze dehydration. Various aspects of freeze drying like heat and mass transfer, retention of flavours and principles of industrial freeze drying etc. have been taken care of in one chapter.

No food processing is complete without adequate functional packaging. The authors have rightly reserved the final and concluding chapter for food packaging. The properties and behaviour of different types of rigid, semi-rigid and flexible packagings have been explained with sufficient theoretical principles so as to enable the reader to appreciate and realise the importance of packaging.

The book is an excellent monograph of principles of food preservation and will be a valuable asset to those who are interested in food science. A small printing error has been noted by the present reviewer. In page 394, reference numbers 23, 24 and 25 are missing.

T. R. SHARMA

Coffee Solubilization—Commercial Processes and Techniques: Food Technology Review No. 28 by Nicholas D. Pintauro, Noyes Data Corporation, Park Ridge, New Jersey, 1975.

The first publication of Food Processing Review No. 8 on Soluble Coffee Manufacturing Processes by the same author brought out the significant manufacturing processes for producing soluble coffee giving practical information based on the U.S. patent literature covering upto 1969. In this edition the detailed infor-

mation based on the U.S. patents dealing with commercial processes and modern techniques involving roasting, extraction, drying processes, aromatisation and agglomeration, decaffeination and finally packaging of coffee products and different processes have been covered up to 1975. The patent literature covers most of the information in the field which is not available in the Journal literature and hence is very valuable for technological transfer of the different techniques described in this book. The presentation of the book giving the table of contents as subject index and other indexes by company, inventor and patent number is highly useful as a ready reckoner for getting the required information on the subject.

The text is broadly divided into different chapters concerning several roasting techniques such as puffing, fluidized bed roasting, compression roasting and ionising roasting, counter current extraction, special extraction, filtration and concentration for producing coffee concentrate beads, recovery techniques for aromatic volatiles by recovery of coffee oil and flavour enhancement and fortification of soluble coffee by microencapsulation and foam mat drying and use of flavour additives and fixatives. The book also describes freeze drying processes with improved flavour and aroma retention for soluble coffee manufacture, agglomeration techniques for improvement of flavour in soluble coffee manufacture and also manufacture of decaffeinated soluble coffee using different solvents and also manufacture of decaffeinated green coffee by solvent extraction using counter current extraction methods and desolventisation. The last chapter describes different packaging methods used to improve the shelf life of various types of coffee products some of them with improved nutritional value including coffee concentrates, freeze dried and spray dried instant coffee and special products and processes such as coffee wafers, coffee tablets and roll-milled coffee, etc.

This book is of vital interest to those concerned with research and development work in different areas of coffee technology and also to coffee industry. This is also a valuable reference and guide book.

N. GOPALAKRISHNA RAO

Edible Starches and Starch-derived Syrups: by Nicholas B. Peterson, Published by Noyes Data Corporation, Park Ridge, New Jersey, 1975.

The book entitled "Edible Starches and Starch-derived Syrups" is yet another classified American patent literature collection compiled by Nicholas B. Peterson and published by Noyes Data Corporation on the subject of edible starches, chemically modified starches and hydrolysed products prepared from them. The book is a good technical review of commercial processes either currently practised or having a potential for use in this field. The review is in 11 Chapters devoted to individual subjects.

Two initial Chapters deal with isolation and utilisation of native starches from food materials and the effect of simple processes like solvent extraction, toasting, oxidation, etc. on their technological properties. This is followed by an interesting Chapter on gelatinised starches covering the processing technology of heat gelatinisation and the use of such heat modified starch in food products.

The next two Chapters relate to esterified and ether linked starches. Esters with carboxylic and phosphoric acids as also cross linked derivatives of these and their use in snack food manufacture are covered. The starch ethers mainly covered relate to hydroxypropylated derivatives.

The Chapter on amylose and amylopectin is most interesting and covers the recently practised enzyme processes for amylose production and the production of the enzyme 1-6 glucosidase. Specific uses of high amylose starch and waxy amylopectin type straches in food industry are also described. Probably this Chapter could have been more appropriately presented earlier immediately after the Chapter on starch isolation.

Dextrin and other starch degraded products with a low molecular weight having desirable properties like reduced viscosity, increased solubility or solubilisation with low degree of sweetness, etc are treated in the next review. The methods of acid hydrolysis, enzyme conversion with alpha and beta amylases as also combined acid-enzyme treatment to effect dextrinization have been described in detail. An account of the use of such products in confectionery practice, special infant and other dietetic proprietary foods, breakfast cereals, etc is also given.

The last part of the book describes the technology of manufacture and utilization of starch based syrups in liquid and solid forms and with varying degrees of purity to meet various food, feed and pharmaceutical needs. The principles and practises of the recently used commercial processes using the enzyme method for starch hydrolysis are fully described. Methods of spray drying of total syrup and crystallization of dextrose by different methods are detailed in a separate Chapter. Processes for maltose and other low oligosaccharides, their use in confectionery as also the production and use of sugar alcohols from the maltose syrups are also covered in the next review. The last Chapter details the technology of fructose production. Both alkaline and enzymic methods of isomerisation to convert glucose to fructose are described in detail in this Chapter.

This book gives a detailed account of the recent U.S. patent information on the subject of edible starches, modified starches and different starch conversion products arranged and classified conveniently for study and reference. It is a very useful book for the scientist and processor and would be a guide to R & D work in the field. The book is illustrated with appropriate examples in proper context.

H. S. R. DESIKACHAR

Proceedings of the International Food Industries Congress: London, May 12-16, 1975, Food Trade Press, London, 1975.

"The International Food Industries Congress was designed to examine and discuss present and future problems in food production, conservation and processing problems which must be solved in order for mankind to survive". This laudable aim does not appear to have received full justice when one peruses the titles of papers presented. Apparently there is no uniformity in the level of coverages and a random approach in the selection of papers. The four themes of the Congress have not received an equitable attention. The papers in general attempt to bring out the problems of the food trade *vis a vis* the changing pattern of food consumption and distribution in the United Kingdom. A few of the surveys that stand out are: Milk Processing and Manufacture—Past, Present and Future possibilities (T.R. Ashton), Intermediate Technology for Food Utilization in the Developing Countries (J. T. Worgan) the Baking Industry (T. C. Shaw) and Packaging of Meat and Meat Products (T. E. Davies). Quite a few papers tend to be propaganda material for the company products although emphasizing some innovations. The paper "Single-cell Protein as a Feedstuff" (T. Walker) elegantly summarises the present status of toxicological and nutritional information. Other topics deal with food hygiene, pest control, laminates as packaging material, oceans as sources of food, etc.

A few innovations that have been brought out include "ice-vacuum pack" for fish, uneven glazing of meat, pellet freezing for liquid foods, multineedle injection of nutrients to pre-rigor meat to manipulate flavour, smoke fog treatment to herrings, preparation and use of natural vegetable extracts as flavouring agents.

The progress in the food industry in the advanced countries has been towards greater automation, increased speed of operations, packaging to suit the supermarket and hypermarket mode of distribution and home-freezer storage and development of convenience foods. In food production, as high a conversion ratio as possible is being attempted even at the risk of deterioration of quality of raw foods. From the latter angle, the possibility of controlling quality of fruit and vegetable by proper nutrient supply to crops (J. Maroussas) and improving the flavour and succulence characteristics of beef, pork and poultry by the injection of nutrients and flavourings (R.J.H. Pannell) appear to be promising lines of future research.

The usefulness of the papers would have enhanced if proper references were included. The printing and production of the book-leave much to be desired.

D. V. REGE

New Members

Dr. C. R. Soman, D-19 Jawaharnagar, Trivandrum 695 003.

Mr. C. Krishnaswamy, CSIR Complex, Trivandrum 695 019.

Mrs. Kurien Thomas, Mariana Food Products, Kawdiyar, Trivandrum.

Mr. K. P. Prasad, 'Aswathy' TC 2/190, Kesavadasapuram, Trivandrum-695 004.

Mr. R. Hariharan, Krithika Agencies, 34/361 Karippukoikkal, Fort, Trivandrum-23.

Mr. Jhala Dilipsinh Pratapsinh, 40/4 L-Colony, Ahmedabad-380 015.

Mr. Mistry Kiran Chandulal, BL-2 Chandan Niwas, Bajaj Road, Ville Parle (West), Bombay-400 056.

Mr. N. R. Mahajan, Room No. 11, Jagriti Sahakari Nivas Mandal, Bhatwadi, Ghatkopar, Bombay-400 086.

Mrs. Srimathi Yeshwant Nayak, 2/6B Postal Colony, Chembur, Bombay-400 071.

Mr. Saeed Ahmed H. Dilawarkhan, J-26 Second Rabodi, Thana-1 (Maharashtra).

Mr. P. Krishna Kumar, Room No. 6, Khalsa College Hostel, Matunga, Bombay-400 019.

Mr. Tendulkar Laxmikant Dayaram, Shri Vishnu Mills Compound, 22 Belvedar Road, Maxagaon, Bombay-400 010.

Mr. L. X. Rangel, Khalsa College Hostel, Matunga, Bombay-400 019.

Mr. C. J. K. Henry, 118 University Hostel, Department of Chemical Technology, Matunga, Bombay-400 019.

Mr. Rege Pratap Balachandra, Swastik House, Dr. Bhadkamkar Marg, Bombay-400 007.

Miss Raval Ratnaprabha, c/o N. J. Raval, 203 Matruashish, Chandaverker Road, Borivilli (West), Bombay-400 092.

Mr. Omprakash K. Misra, 140, University Hostel, Matunga, Bombay-400 019.

Mr. M. M. Khan, 4/132 Reay Road, Bombay-400 010.

Mr. A. D. Samson, Plot No. 530 12th Road, Catholic Colony, Chembur, Bombay-400 071.

Mr. N. Ramasubramanian, L-3 University Hostel, Matunga, Bombay-400 019.

Mr. Kumar Padmanabh, c/o K. M. Menon, Port Inspector's House, Indira Dock, Bombay-400 038.

Mr. C. K. Narayanan, 1323, Sector IV, CGS Quarters, Antop Hills, Bombay-400 037.

Mr. R. Iyer Kuppuswamy, c/o Mr. M. B. Kannan, J. Block, 102 Sundaranagar, Malad, Bombay-400 062.

Mr. V. A. Inamdar, 31 Dadbhawala Sadan, Telang Road, Matunga, Bombay-400 019.

Mr. P. B. Bondre, Joshi Bunglow, Behind Railway Goods Shed, Thana-2 (Maharashtra).

Mr. N. Asohan, 112 University Hostel, Matunga, Bombay-400 019.

Mr. V. Thiraviam, 104 University Hostel, Matunga, Bombay-400 019.

Mr. G. S. Kansagara, 115 New UDCT Hostel, Matunga, Bombay-400 019.

Mr. T. Nisar Premji, 418(3), 2 Chaya Society, Chembur Naka, Bombay-400 071.

Mr. P. D. Rangnekar, 5 Mayuresh, L. J. Cross Road, Mahim, Bombay-400 016.

Mr. A. Ramesh, Scientist, Process Development Discipline, CFTRI, Mysore-570 013.

Mr. Prakash Nath, 106 Babar Road, New Delhi-110 001.

Mr. Ravi Shankar Sharma, 38 Sukhimal Street, Subhash Gate, Ghaziabad.

Mr. S. S. Verma, 98 P. G. Hostel (New Wing), Indian Agricultural Research Institute, New Delhi-110 012.

Kum. M. Lalitha, Plot No. 2642, Annanagar, Madras-600 040.

Mr. N. S. Sankaran, Technical Assistant, Salt Fortification Project, 7-A Gopalapuram Street, Madras-600 086

Ch. Subba Rao, National Fruit Flavour Co. Inc., 421, Girod Street, New Orleans, La 70130, United States of America.

Mr. K. B. Kohli, c/o Dayaram & Co., S. R. Gunj, Srinagar-2 (J & K State).

Dr. R. Radhakrishnan, Institute of Veterinary Preventive Medicine, Ranipet-632402.

Dr. Palle Krogh, University Institute of Pathological Anatomy, Juliane Maries VEJ 16, DK-2100, Copenhagen, Denmark.

Dr. K. O. Herz, FAO-ESN-C 641, 00100 Rome, Italy.

Mr. Subhash Chander Malhotra, Deputy Brew Master, Devans Modern Breweries Ltd, Jammu-2 (J & K State).

Dr. Vidya Sagar, Associate Professor, Food & Nutrition, Haryana Agricultural University, Hissar-125 004 (Haryana).

Mr. O. P. Dhamija, Joint Director, Export Inspection Council, 3 Tolstoy Marg, New Delhi-110 001.

Mr. G. M. Parekh, Krishna Flour Mills, 19 Platform Road, Bangalore-560 023.

Mr. A. Basrah Enie, Chemical Research Institute, Jl ir H. Juanda 5, Bogor, Indonesia.

Mr. Fikret Nafi Coksoyler, Gida Isleri Benel Mudurlugu, P. K. 36, Yenimahalle, Ankara, Turkey.

Mr. S. K. Jain, 9/376 Jawaharnagar, Trivandrum-695 003.

Mr. K. S. K. Panicker, Junior Statistical Officer, Integrated Nutrition Planning Programme, 9/376 Jawaharnagar, Trivandrum-695 003.

Mrs. Anna George, Professor & Head, Home Science Department, College of Home Science, Trivandrum.

Dr. L. Prema, Lecturer in Nutrition, College of Agriculture, Vellayani-695 522.

Dr. K. N. Syamasundaran Nair, Deputy Director (Agriculture), State Planning Board, Trivandrum-695 004.

Mr. Madan Mohan Verma, CFTRI, Hostel—B:6, Mysore-570 013.

Mrs L. Suseela Devi, Assistant Professor, Department of Soil Science, University of Agricultural Sciences, Hebbal, Bangalore-560 024.

Mr. J. P. Bajpai Food Inspection Unit, ASC (ADF) Agra Cantt.

Mrs Eva Sunderarajan, Institute of Hotel Management, Catering Technology and Applied Nutrition, Dadar, Bombay-400 028.

Mr. Jagannath Das Agrawal, C/o Allahabad Canning Co. Bamrauli, Allahabad.

Smt. Satyabhama Ghosh, 1A, Harisara Street, Calcutta-700 023.

Mr. Samir Kumar Ghosh, 30 Maharaja Nandakumar Road, Calcutta-700 036.

Mr. Manoranjan Pal, 48/1 Serpentine Lane, Calcutta-700 014.

Mr. Madhusudan Bandyopadhyay, M-20 Kalkaji, New Delhi-110 019.

Mr. Bhim Sain Bahry, 65/11 Rohtak Road, Karol Bagh, New Delhi-110 005.

Mr. Vinayak Wasudeo Kulkarni, Research Scholar, University Department of Biochemistry, Mahatma Gandhi Road, Nagpur-440 010.

Mr. Ramesh Shyam Ramteke, FVT Discipline, CFTRI, Mysore-570 013.

Dr. Mudambi V. Rajagopal, Department of Microboiology, University of Nigeria, Nsukka-Nigeria.

Mr. Manhar N. Patel, Honorary Secretary, A. P. Grape Growers Association, Mansoorabad, Hyderabad-500 035.

Mr. S. Cartic, (Veenus Food Products Ltd), 43 Parameswari Nagar, Madras-600 020.

Mr. K. H. Krishnan, Senior Technical Assistant, Quality Control Laboratory, Government of India, P. N. Palayam, Coimbatore-37.

Mrs. B. K. Padmini, 2–1–58/1 Nallakunta, Hyderabad-500 044.

Dr. B. N. Kowale, Junior Research Officer, Division of Livestock Products Technology, Indian Veterinary Research Institute, Izatnagar-243 122.

Dr. V. N. Bachhil, Junior Research Officer, Division of Livestock Products Technology, Indian Veterinary Research Institute, Izatnagar-243 122.

Mr. K. Nageswara Rao, Division of Poultry Research, Indian Veterinary Research Institute, Izatnagar-243 122.

Mr. S. V. Ramakrishna, Fermentation Technology Discipline, CFTRI, Mysore-570 013.

Mrs. Suneetha U. Rajanahally, P. B. No. 54, Davanagere-577 001.

ANNOUNCEMENT

INTERNATIONAL FAIR OF FOOD BEVERAGES AND MACHINES

The 2nd International Fair of Foods—Beverages and Machines is going to be held in Thessaloniki—Greece, from 17th to 24th April 1977. Those who are interested may write for further details to

Mr. CONSTANTINOS SKYFALIDES

DIRECTOR

THESSALONIKI INTERNATIONAL FAIR

THESSALONIKI, GREECE

(Cables: FOIRINT)

International Exhibition for the Food & Allied Industries

The 10th International Exhibition for the London Food and Allied Industries takes place at the National Hall, Olympia, from 15 to 18th November, 1977.

The food Industries Exhibition covers in depth all aspects of food manufacture, handling and distribution including canned, frozen chilled and dried foods, bakery goods and confectionery, meat, poultry and other fresh foods, milk products, and soft drinks. Exhibits include ingredients and flavouring, process plant and machinery, filling and packaging equipment and machinery, labels and labelling systems, specialised mechanical handling equipment, and other products used by food manufacturers, packers and distributors.

Further information may be obtained from

BPS EXHIBITIONS LTD.

4 SEAFORD COURT

220-222 GREAT PORTLAND STREET

LONDON WIN 5HH

TEL: **01-388 2117** TELEX: **21237** CABLES: **BEEPEX LONDON**

SEMINAR

Problems and Prospects of Solvent Extraction Industry in India

Oil Technologists' Association of India - Southern Zonal Branch

It has been proposed to organise a one and half-day Seminar on "Problems and Prospects in Solvent Extraction Industry in India", on 11th and 12th December 1976, at Regional Research Laboratory, Hyderabad.

The Solvent Extraction Industry has grown from a dozen units to hundreds of units with phenomenal progress on extraction of oilcake. The curbs on export of expeller cake and incentives offered to encourage export of extracts had added vitality to the industry. While these are encouraging signs, the industry has still to tackle several new problems, technical as well as trade, to make further progress and consolidate its position in competitive industry.

The objective of this Seminar is to highlight these problems and prospects. The Seminar is expected to bring together industrialists, research scientists and technologists, government executives, processors, and plant manufacturers and afford an opportunity to discuss their individual problems, chalk out areas of mutual cooperation, coordinate their efforts on improvements, consolidate the gains achieved and sort out areas and fields where further work/improvements are needed to bring the industry on par and gainfully competitive to international levels. It is intended to highlight these problems under the following:

1. Raw material
2. Plant and machinery
3. Products and processes
4. Government rules, regulations and policies
5. Current research and other matters
6. Panel discussion and recommendations

We invite your views and papers on all these aspects for presentation. Discussion in the Seminar will be centered on the background information, collected by the organisors.

Participating Machinery manufacturers who intended to exhibit or highlight their plant features will be given all facilities to exhibit charts, products, raw materials or machineries during the Seminar.

For further details write to:

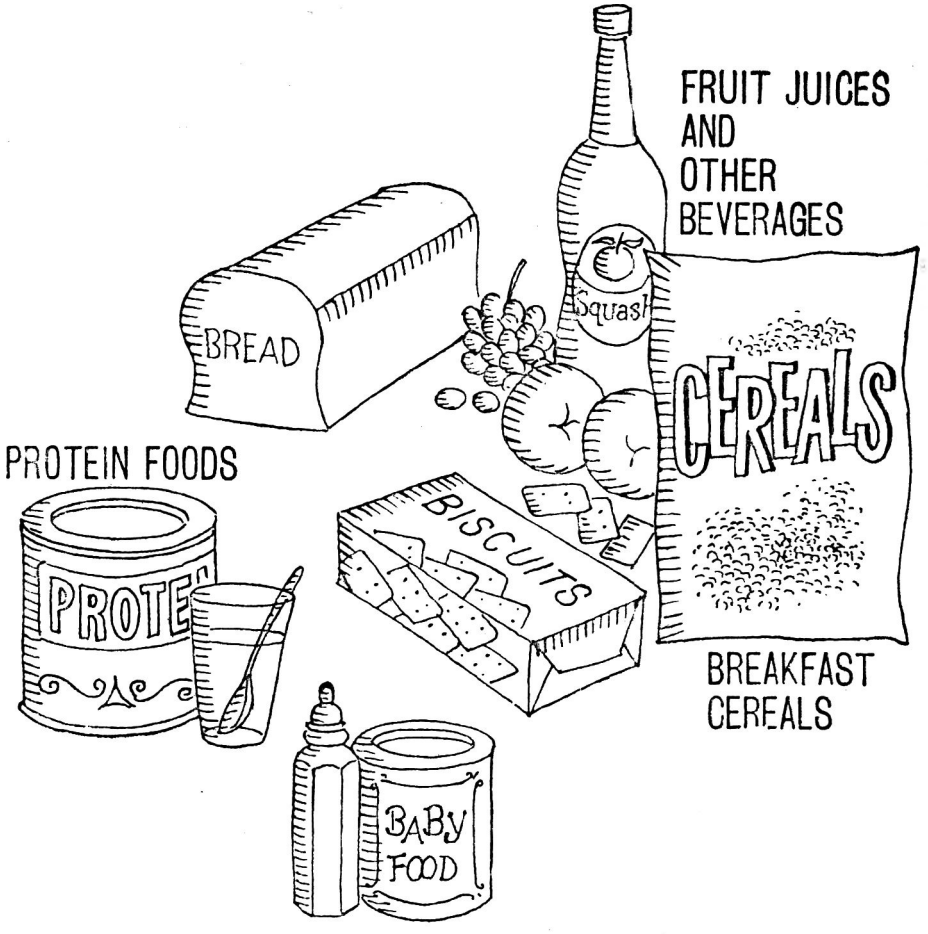
Dr. J. P. MISRA

Honorary Secretary

O. T. A. I. (SZB)

HYDERBAD—500 009 (A.P.)

FORTIFY



with Roche Vitamins

Vitamin Premixes containing Vitamin A and other vitamins like B_1, B_2, D, E can be made to suit your specific requirements. For further details regarding levels to be added, methods of incorporation etc., please contact the Sole Distributors: Voltas Limited.

Premixes can also be used in :
Malted Milk Foods
Confectionery
Weaning Foods.

Manufactured by:

ROCHE

ROCHE PRODUCTS LIMITED
28, Tardeo Road,
Bombay-34 WB

INSTRUCTIONS TO CONTRIBUTORS

1. Manuscripts of papers should be typewritten in double space on one side of the paper only. They should be submitted in **triplicate.** The manuscripts should be complete and in final form, since no alterations or additions are allowed at the proof stage. The paper submitted should not have been published or communicated anywhere.

2. Short communications in the nature of Research Notes should clearly indicate the scope of the investigation and the salient features of the results.

3. Names of chemical compounds and not their formulae should be used in the text. Superscript and subscripts should be legibly and carefully placed. Foot notes should be avoided as far as possible.

4. **Abstract:** The abstract should indicate the scope of the work and the principal findings of the paper. It should not normally exceed 200 words. It should be in such a form that abstracting periodicals can readily use it.

5. **Tables:** Graphs as well as tables, both representing the same set of data, should be avoided. Tables and figures should be numbered consecutively in Arabic numerals and should have brief titles. Nil results should be indicated and distinguished clearly from absence of data.

6. **Illustrations:** Line drawings should be made with *Indian ink* on white drawing paper preferably art paper. The lettering should be in pencil. For satisfactory reproduction, graphs and line drawings should be at least twice the printed size. Photographs must be on glossy paper and contrasty; *two copies* should be sent.

7. Abbreviations of the titles of all scientific periodicals should strictly conform to those cited in the World List of Scientific Periodicals, Butterworths Scientific Publication, London, 1962.

8. **References:** Names of all the authors should be cited completely in each reference. Abbreviations such as *et al.*, should be avoided.

   In the text, the references should be included at the end of the article in serial order.

   Citation of references in the list should be in the following manner:

   (*a*) *Research Paper:* Menon, G. and Das, R. P., J. sci. industr. Res., 1958, **18,** 561.

   (*b*) *Book:* Venkataraman, K., The Chemistry of Synthetic Dyes, Academic Press, Inc., New York, 1952, Vol. II, 966.

   (*c*) *References to article in a book:* Joshi, S. V., in the Chemistry of Synthetic Dyes, by Venkataraman, K., Academic Press, Inc.. New York, 1952, Vol. II, 966.

   (*d*) *Proceedings, Conferences and Symposia:* As in (*c*).

   (*e*) *Thesis:* Sathyanarayan, Y., Phytosociological Studies on the Calcicolous Plants of Bombay, 1953, Ph.D. thesis, Bombay University.

   (*f*) *Unpublished Work:* Rao, G., unpublished, Central Food Technological Research Institute, Mysore, India.

REG. No. 24918/64

Printed and published by Shri M. M. Krishnaiah Secretary AFST (India) CFTRI, Mysore-570013, at Sharaca Press, Mangalore-575001